SPGR Sub-Project Completion Report

Project Title
Coordinated Sub-Project on
Characterization of Important Plant Genetic Resources:
BAU Component

Duration: December 2011 to June 2014

Executing Organization

Fruit Tree Improvement Program (FTIP)
BAU Germplasm Center
Bangladesh Agricultural University
Mymensingh

Submitted to

PIU-BARC, NATP: Phase-1
BARC Complex
Farmgate, Dhaka-1215

June 2014

SPGR Sub-Project Completion Report

Project Title
Coordinated Sub-Project on

Characterization of Important Plant Genetic Resources: BAU Component

Duration: December 2011 to June 2014

Executing Organization

FTIP-BAU Germplasm Center
Department of Horticulture
Bangladesh Agricultural University
Mymensingh

Submitted to

PIU-BARC, NATP: Phase-1
BARC Complex
Farmgate, Dhaka-1215

June 2014

Table of Contents

SL. No.	Contents	Page
	Cover page	i
	Table of contents	ii
	List of tables& figures	iii
	List abbreviations	iv
	Executive summery	v
1.	Sub-project title	1
2.	Principal Investigator/Co-principal Investigator	1
3.	Full address of PI and Co-PI	1
4.	Duration of the sub-project	1
5.	Date of approval	1
6.	Total approved budget	1
7.	Justification of undertaking the sub-project	1
8.	Sub-project objectives	1
9.	Methodology followed in conducting research	2
10.	Results and discussion	7
11.	Research highlight	97
12.	Environmental matrix	97
13.	Major attainments	98
14.	Sub-project auditing	101
15.	Reporting	101
16.	Problems/Constraints	101
17.	Suggestion for future research	101

List of Tables

SL No.	Title	Page
1.	Name of crops and number of GI crops, varieties, cultivar and genotypes as per project proposal	2
2.	Target of characterization revised based on the suggestion/recommendation of coordination meeting, workshop considering national interest	2
3.	Achievement (Characterization done)	2
4.	Primer code used for the detection of polymorphism of GI guava and jujube	5
5.	Primers sequence used for RAPD analysis of guava	5
6.	Primers sequence used for RAPD analysis of jujube (kul/ber)	5
7.	The distinguished difference among the GI guava varieties	12
8.	The distinguished difference among the GI varieties of jujube (kul/ber)	19
9.	RAPD primers with corresponding bands score range together with polymorphic bands observed in 14 jujube genotypes	20

List of Figures

SL No.	Title	Page No.
1.	Extracted genomic DNA of GI guava varieties	12
2.	RAPD profile of 14 jujube genotypes using primer OPC15	21
3.	RAPD profile of 14 jujube genotypes using primer OPD03	21
4.	RAPD profile of 14 jujube genotypes using primer OPF02	22
5.	RAPD profile of 14 jujube genotypes using primer OPF03	22
6.	RAPD profile of 14 jujube genotypes using primer OPF11	23
7.	Unweighted pair group method of arithmetic mean (UPGMA) dendrogram based on Nei's (1972) genetic distance, summarizing data on differentiation in 14 jujube (ber/kul) genotypes according to RAPD analysis	23

Abbreviations

BAU	Bangladesh Agricultural University
BAU-GPC	Bangladesh Agricultural University Germplasm Center
CTAB	Cetyl Tri methyl Ammonium Bromide
DNA	Deoxirybo Nuclic Acid
EDTA	Ethylene Diamine Tetra Acitic Acid
GI	Geographical Indication
IPGRI	International Plant Genetic Research Institute
MC	Moisture content
NRS	Non-reducing Sugar
PCR	Polymerase Chain Reaction
RAPD	Random Amplified Polymorphic DNA
RS	Reducing Sugar
SAAO	Sub-Assistant Agriculture Officer
SAPPO	Sub-Assistant Plant Protection Officer
TS	Total Sugar
TSS	Total Soluble Solids
UAO	Upazila Agriculture Officer
UPGMA	Unweighted Pair Group Method of Arithmetic Means

Executive Summary

This research work has been under taken in order to study the morphological and molecular characterization of Geographical Indication-crops (GI-crops) mainly the GI varieties of Guava (*Psidium guajava* L.) and Indian Jujube (ber, *Zizyphus mauritiana* L.) and later on GI variety of aroids and indigenous banana (*Musa spp.*) have been included. In addition to those GI crops, other released fruit varieties from FTIP-BAU-germplasm center has also been studied. *In situ* data on GI crop varieties of guava, jujube, aroids and indigenous banana were collected from the place of its origin where they were existing/cultivating from long period. During *in situ* data collection fresh leaf samples were collected for molecular characterization in the laboratory. Among the GI crops, four GI guava varieties and six GI have been studied both morphological and Molecular level. From the results, it was found that in Bangladesh four GI varieties of guava viz., Sawrupkathi piyara, Mukondapuri piyara, Kancham Nagar piyara and Sayedi piyara have been identified. All GI guava varieties have been characterizes morphologically. In addition, the historical background of those GI crop varieties of guava has been recorded from about 70-100 years old local people. Molecular characterization has also been done for Sawrupkanthi piayara, Mukondopuri piayara, and Kancham Nagar piayara. On the other hand, six GI varieties of Jujube (ber/kul) has been identified during this study. All the GI varieties of jujube/Indian ber viz., Apple kul, Shabjee kul, Zahazi kul, Khacchar kul, Narekeli kul and Kachua kul have been studied at morphological and molecular levels. Moreover, the historical background of those GI crop varieties of jujube has been recorded from about 60-115 years old local people. In addition, some of the released varieties of BAU-GPC specially mango has been characterized morphologically. Initially GI variety aroids and indigenous banana were not assigned in this research component, later on both crops were included. Collection of historical background and morphological characterization of GI crop of aroids viz., Giant taro (Man kachu), Elephant foot yam, Panchamakhi kachu, Poidnal kachu, Salad kachu, Tannia/Dud kachu, Blue taro (Surma kachu), Pani kachu/Shola kachu, Shahebi kachu/Babu kachu and Mukhi kachu have been studied. Moreover, like GI aroids, collection, documentation and morphological characterization of indigenous banana viz., Agnissar, Aita, Anaji, Bangla, Bhuita/Bichi, Champa, Chinicahmpa, Deahi Sabri, Doyra/Doya, Garasundari/ Ganasundari, Jat, Kabri, Kathali, Kulpat/Pulpatkala have also been studied.

Main report content:

1. Sub-Project title: **Characterization of Important Plant Genetic Resources: BAU Component**
2. Principal Investigator/Co-principal investigator(as applicable):
3. Full address with phone, cell and e-mail:

Principal Investigator (PI):

Dr. M. A. Rahim
Professor
Department of Horticulture, Bangladesh Agricultural University, Mymensingh
Tel. No: 0916214, Mobile: 01711854471, Fax No: 09162714
Email: marahim1956@yahoo.com

Co-PI:
(i) Dr. Md. Habibur Rahman
Professor
Dept. of Horticulture, Bangladesh Agricultural University, Mymensingh,
Mobile: 01727735271, E-mail: mhrahmand3@yahoo.com

(ii) Dr. Md. Mokter Hossain
Professor
Dept. of Horticulture, Bangladesh Agricultural University, Mymensingh,
Mobile: 01748-020966, E-mail: hossainmdmokter@gmail.com

4. **Duration** of the sub-project: **December 2011 to June 2014**
5. **Date of approval** (by the Executive Council/signing of LoA): December 1, 2011
6. Total approved Budget (Taka): **3882,320.00 (Thirty eight lakh eighty two thousand three hundred twenty taka only)**

Total fund received (Tk.):	3882,320/-
Total fund Spent (Tk.):	3882, 320/-
Unspent/balance fund (Tk.):	0.00/-
Reason for the balance:	-

7. **Justification of undertaking the sub-project** :

As a coordinated project, BAU part has been assigned to characterize (morphological and molecular) GI-crops (Geographical Indication-crops) of guava, jujube (ber/kul) and FTIP-BAU-GPC released mango varieties as well as GI aroids and indigenous banana. Morphological and molecular characterization carried out under this project would be utilized for germplasm conservation, authentication, purification and identification and protection from piracy.

8. **Sub-project objectives :**

The purposes of the project were -

(i) to characterize the morphological features of GI-crop varieties (guava and jujube);
(ii) to characterize GI-crop varieties (guava and jujube) at molecular level using RAPD markers;
(iii) to characterize the morphological features of FTIP-BAU-GPC released mango varieties; and
(iv) to characterize GI aroids and indigenous banana.

9. Methodology followed in conducting research/investigation:

The following methods have been followed for conducting this research project:

i) *In situ* data through direct field visit:

Historical background of GI crop varieties was recorded through direct field visit. History of specific GI crop was noted by taking interview from tree owner, Upazilla Agriculture Officer (UAO), Sub-Assistant Plant Protection Officer (SAPPO), Sub-Assistant Agriculture Officer (SAAO) and 60-115 years old local people.

Table 1. Name of crops and number of GI crops, varieties, cultivar, and genotypes as per project proposal

Name of crops	Target of characterization					
	GI		Variety		Germplasm	
	Mor.	Mol.	Mor.	Mol.	Mor.	Mol.
Guava	4	4	-	-	-	-
Jujube	6	6	-	-	-	-
Mango			17	17	-	-
Total	**10**	**10**	**17**	**17**	**-**	**-**

Mor. = Morphological, Mol. = Molecular

Table 2. Target of characterization of revised crops based on the suggestion/ recommendation of coordination meeting, workshop considering national interest

Name of crops	Target of characterization (Revised)					
	GI		Variety		Germplasm	
	Mor.	Mol.	Mor.	Mol.	Mor.	Mol.
Guava	4	4	-	-	-	-
Jujube	6	6	-	-	-	-
BAU-GPC released mango	-	-	17	17	-	-
*Aroids	10	10	-	-	-	
*Indigenous Banana	-	-	-	-	14	14
Total	**20**	**20**	**17**	**17**	**14**	**14**

Mor. = Morphological, Mol. = Molecular

***Note**: At the end of first year of the project period, GI **aroids** and indigenous **banana** have been included for their morphological and molecular characterization under this project work.

Table 3. Achievement (Characterization done)

Name of GI crops	Characterization done (final output)					
	GI		Variety		Germplasm	
	Mor.	Mol.	Mor.	Mol.	Mor.	Mol.
Guava	4	3	-	-	-	-
Jujube	6	5	-	-	-	-
Mango	-	-	17	-	-	-
Aroids	10	-	-	-	-	-
Banana		-	-	-	14	-
Total	**20**	**8**	**17**	**-**	**14**	**-**

Mor. = Morphological, Mol. = Molecular

Morphological characterization of GI crop varieties viz., guava, jujube (ber), mango, aroids and indigenous banana have been done following IPGRI descriptor. Morphological characters on different attributes such as plant structure, branching habit, stems, leaves, inflorescence, flowers, fruits and seeds were taken carefully for each and every GI crop varieties. Photographs of all components were taken using digital camera.

ii) Molecular analysis:

Plant materials:

Fresh young leaves of GI crop varieties were collected from the place of origin during *in situ* data collection and used as the sources of genomic DNA. After collection, samples were preserved in airtight polythene packet separately, kept in an ice box and brought immediately to the laboratory.

Genomic DNA extraction of guava:

Genomic DNA were extracted from the leaves by CTAB method. At first samples were washed with distilled water. All other equipments (eg. scissor, mortar etc.) were also sterilized by 100% alcohol. Then the leaves were cut into small pieces and took into the mortar. 1000 ml extraction buffer (Tris HCL+EDTA+CTAB) was added and mashed well with the help of pestle. Then it was collected into eppendorf tube and incubation at 65^0C for 15-30 min with 150ml SDS. The mixture was centrifuged 13000 rpm for 15 min and transferred 600 ml supernatant to another clean tube. Add 600 ml P.C.I (Phenol: Chloroform: Isoamyl alcohol (v: v: v= 25:24:1) and vortex 20 sec/finger tapping. The sample was centrifuged at 13000 rpm for 15 min and took 400 ml supernatant and added ice cold Isopropanol+20 ml Na-acetate. The sample was centrifuged 13000 rpm for 10 min and discard the liquids. The DNA precipitate were washed by 600ml 100% ethanol and discard the liquid. Then again added 600ml 70% ethanol and centrifuged. Remaining alcohol was removed from the bottom of the tube carefully and kept 20-30 min at room temperature. The DNA samples were dissolved with 40µl TE buffer. The quality and quantity of DNA were assessed by 1% agarose gel (Fig. 1). The samples were stored at -20^oC.

Genomic DNA extraction of jujube:

Genomic DNA samples were extracted from vigorous young actively growing leaf tissue following modified Doyle and Doyle (1990) method. Initially healthy portion of youngest leaves were taken out and washed in distilled water to avoid any spore of microorganisms. Approximately 0.1g of leaf tissue was grounded with the help of mortar and pestle. The grounded tissues were mix with 400 µl extraction buffer. After adding additional 400 µl extraction buffer, the ground samples were vortexes for 30 second and incubated at 65^0C for 5 minutes in hot water bath. Following further mixing with a vortex mixture for about 20 seconds, the samples were again incubated at the same temperature for approximately 10 minutes and then the extract was centrifuged for 10 minutes at 14000 rpm to allow precipitation to the cell debris. About 500 µl supernatant was transferred to another clean tube then 600 µl of Phenol: Chloroform: Isoamyl alcohol (v: v: v= 25:24:1) was added to it and mixed gently for purification. Then the solution was centrifuged for 10 minutes at 14000 rpm. DNA was precipitated first using about 800 µl of absolute alcohol and pelleted by centrifugation for 15 minutes at 14000 rpm. After discarding the liquid completely, the DNA

solution was re-precipitated by adding 400 µl of 70% ethanol with 20 µl 3 M sodium acetate and pelleted by centrifugation for 10 minutes at 14000 rpm. When the liquid removed completely, the pellets were then air dried for 20-30 minutes and re-suspended in 25 µl of TE buffer. The quantity and the quality of isolated DNA were assessed by using 1% agarose gel.

Amplification of RAPD markers by PCR:

i) Principles of the amplification of RAPD

In the presence of a thermostable DNA polymerase, a single oligonucleotide of arbitrary DNA sequence is mixed for performing amplification of RAPD with genomic DNA and a suitable buffer, to temperature cycling conditions typical to PCR. Amplification depends on the sequence and length of the oligonucleotide and the reaction conditions. During the application of thermal cycling and an appropriate annealing temperature, the single primer binds to sites on opposite strands of the genomic DNA that are witching and amplifiable distance from each other in which case a discrete DNA segment is produced. The presence or absence of this specific product, although amplified with an arbitrary primer, will be diagnostic for the oligonucleotide binding sites on the genomic DNA. In practical terms, the DNA amplification reaction is repeated on a set of DNA samples with several different primers, under conditions that result in several amplified bands from each primer. With the help of gel electrophoresis, polymorphic bands were recorded and the polymorphisms can be mapped in a segregating population. Sometimes a single primer may be used to identify several polymorphisms, each of which matches a different locus of DNA.

ii) Selection of primers

A total of 40 decamer primers (20 for GI guava and 20 for GI jujube) (oligonucleotieds) of arbitrary sequence (Operon Kits OPA, OPB, OPC, OPD, OPE, and OPF) were screened (Table 4) on a sub-sample of two randomly chosen both for GI guava and GI jujube germplasm, to test their suitability for amplifying RAPD that could be accurately scored. RAPD analysis of guava was done with 5 primers (Table 5). On the basis of intensity or resolution of bands, repeatability of markers and consistency within individuals and the potential to differentiate 20 exhibiting good quality banding patterns was selected for the analysis of the whole sample set of the 14 jujube germplasm. A final subset of 5 primers for jujube (Table 6) out of 20 exhibiting good quality banding patterns was selected for the analysis of the whole sample set of the 14 genotypes of jujube. For more confirmation, the reproducibility of RAPD markers was repeated three times.

iii) PCR amplification for RAPD

Amplification was carried out following the protocol of Williams *et al.,* (1990) with some modifications. The reaction mixtures were prepared in a volume of 10 µl containing 1 µl 10 x AmpliTaq polymerase buffer, 0.25 µl of primer, 1µl dNTPs, 1 unit of AmpliTaq DNA polymerase (Bangalore Genei, India) and 4µl (100 ng) genomic DNA and rest amount of sterile deionized water. DNA amplification was performed in an oil-free thermal cycler (Master cycler Gradient, Eppendorf), programmed as follows: 5 minutes at 94^0 C for initial strand separation followed by 45 cycles comprising 1 minute denaturation at 94^0 C, 1 minutes annealing at 37^0 C and elongation or extension at 72^0 C for 2 minutes. An additional cycle of 7 minutes at 72^0 C was used for final extension.

Table 4. Primers used for the detection of polymorphism of GI guava and jujube

Guava		Jujube	
SL. No.	**Primer**	**SL. No.**	**Primer**
1.	OPA 02	1.	OPC 03
2.	OPA 05	2.	OPC 06
3.	OPA 07	3.	OPC 11
4.	OPA 08	4.	OPC 15
5.	OPA 09	5.	OPC 18
6.	OPA 10	6.	OPD 03
7.	OPA 11	7.	OPD 04
8.	OPA 12	8.	OPD 07
9.	OPA 14	9.	OPD 11
10	OPB 02	10	OPE 02
11.	OPB 03	11.	OPE 13
12.	OPB 05	12.	OPE 19
13.	OPB 07	13.	OPE 20
14.	OPB 12	14.	OPF 01
15.	OPB 13	15.	OPF 02
16.	OPB 15	16.	OPF 03
17.	OPB 17	17.	OPF 08
18.	OPB 19	18.	OPF 11
19.	OPC 20	19.	OPF 12
20.	OPD 08	20.	OPF 15

Table 5. Primers sequence used for RAPD analysis of guava

Primer	Sequences (5′-3′)	% (G + C)
OPB 02	TGATCCCTGG	60
OPA 05	AGGGGTCTTG	60
OPB 07	GGTGACGCAG	70
OPA 10	GTGATCGCAG	60
OPB 12	CCTTGACGCA	60

Table 6. Primers sequence used for RAPD analysis of Jujube (kul/ber)

Primer	Sequences (5′-3′)	% (G + C)
OPC 15	GACGGATCAG	60
OPD 03	GTCGCCGTCA	70
OPF 02	GAGGATCCCT	60
OPF 03	CCTGATCACC	60
OPF 11	TTGGTACCCC	60

iv) Electrophoresis

Amplification products for each sample was separated by electrophoresis in 1.5% agarose gel (Fisher Biotech, USA) containing ethidium bromide in 1 x TBE buffer at 120 V for 1 hour, a molecular weight marker DNA (pUC 18/Sau 3A1-pUC 18/Taq1 Digest and 100 bp ladder) was electrophoreses alongside the RAPD reactions. DNA bands were observed on computerized UV light chamber and photographed by computer with the help of color printer.

Data analysis

The RAPD bands were scored visually on the basis of their presence. (1) or absence (0) separately for each accessions of jujube and each primer. Bands not identified by the two readers were considered as no-scorable. The scores obtained using all primers in the RAPD analysis were then pooled for constructing a single data matrix. This was used for estimating polymorphic loci, Nei's (1973) gene diversity, population differentiation (GST), gene flow (Nm,) genetic distance (D) and constructing a UPGMA (Unweighted Pair Group Method of Arithmetic Means) dendrogram among populations using POPGEN (Version 1.31) (Yeh *et al.,* 1999) computer program. The same program was also used to perform test of homogeneity in different locus between population pairs.

Gene frequencies of RAPD loci were estimated based on the assumption of a two alleles system. From the two alleles only one is capable of amplification of a RAPD band by primer annealing at an unknown genomic position (locus). The other is the "null" allele which is incapable of amplification, mainly because of loss of the primer-annealing site by mutation. The two alleles assumption is in most cases acceptable, because co-dominant loci showing band shifts are few (Elo *et al*., 1997; Welsh and McClelland, 1990). In these cases only a null homozygote is detectable as negative for the RAPD band of interest. Under the assumption of the Hardy-Weinberg equilibrium, the null allele frequency (q) may be (N/n) 1/2, where N and n are the number of band negative individuals observed and the sample size, respectively. The frequency of the other allele (P) is 1-q. The assumption of the two alleles system enables one to calculate the Nei's genetic distance (Nei, 1972) from the RAPD pattern.

10. Results and Discussion

A. Characterization of GI crop varieties:

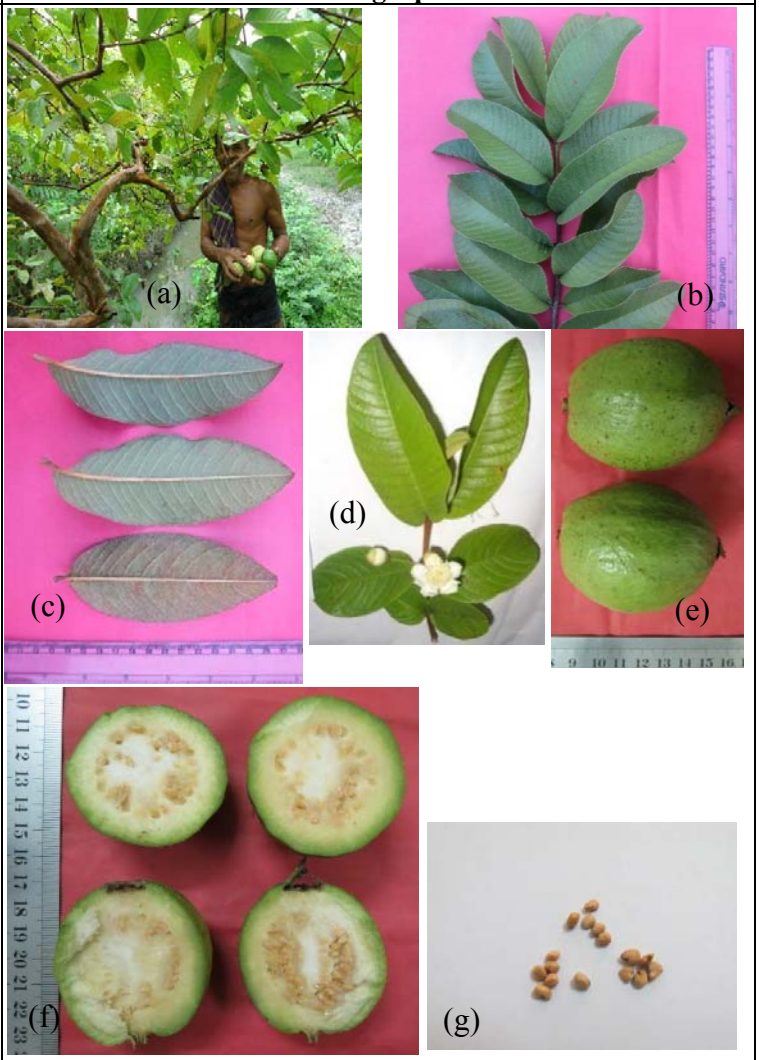
A.1 Morphological and molecular characterization of GI guava

Guava is one of the major fruit crops in Bangladesh. A number of variety or cultivars are growing in the country from the time immemorial. The local, GI and indigenous guava varieties are needed to be characterized to protect from piracy.

A. 1.1 Historical background of Swarupkathi Piyara:

Swarupkathi piyara is one of the ancient variety of guava which named is directly related to its locality Swarupkathi upazila, the formar name of Nesarabad Upazila under the District of Pirojpur of Bangladesh. Information was collected from 80 years aged old man named Moti Lal Mondal. Cultivation of this variety has been continuing in the village Atghor-Kuriana for more than 60 years and now widely cultivated in many parts of the coutnry. This is very famous guava in this area for its higher yield and taste. Market price of this guava is always higher compared to other guava.

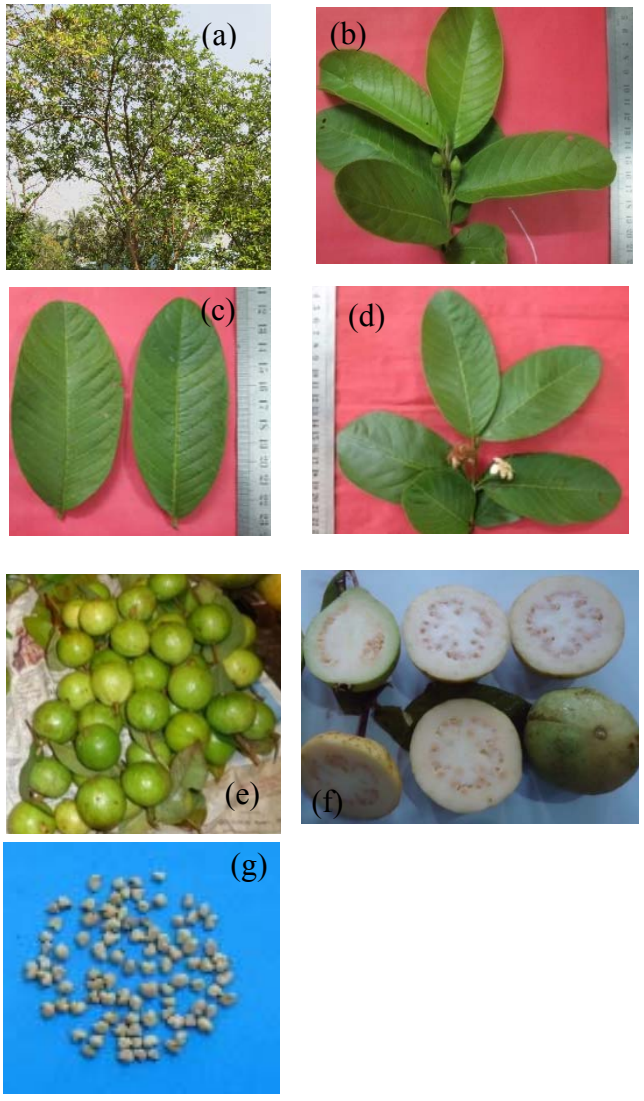
Morphological characterization of Swarupkathi Piyara:

Morphological characters	Photographs
Plant description: Plants are medium height (5-6m) and branched (Fig. 1.1a). **Stem:** Stems are less branching, smooth surface (Fig. 1.1a). **Leaf:** Simple leaf, petiole short, leaf length 13.6-14.0cm, apex semi acute, base obtuse, leaf width 5.0-6.5 cm, dorsal surface smooth, ventral surface rough, light green color, veins are prominent in the dorsal side of the leaf (Fig. 1.1b, c). **Flower:** White color flowers are appeared from the axillary position of leaves. Flowers are 5 petals and numerous stamens (Fig. 1.1d). **Fruit:** Fruits are globose, round, somewhat rough surface, flesh creamy white color, medium crispy, taste sweet, total soluble solids 12.93% brix, moisture 86.12% (Fig. 1.1e, f). **Seed:** Seeds are almost soft at early maturity stage, edible, brown color, medium size, flattened, angular (Fig. 1.1g).	 Fig. 1.1 Morphological characterization of Swarupkathi Piyara

A.1.2 Historical Background of Kanchan Nagar Piyara:

A gentleman named Mr. Abdus Salam age of 102 years provided information's about Kanchon Nagar piyara. He told that this piyara has been cultivation in this area since 1918. At the beginning cultivation of this guava was in a small scale. Later on this guava variety got reputation to the villagers and after that it spread in most of the peoples of the village Kanchan Nagar, Upazilla-Kanchan Nagar, and district-Chittagong. Now it is commercially cultivated and covers about 2.5-3.0 thousand acres of land. There were two colored varieties (pink and white flesh), pink color variety is no longer cultivating, only the white flesh variety is now cultivating in this area.

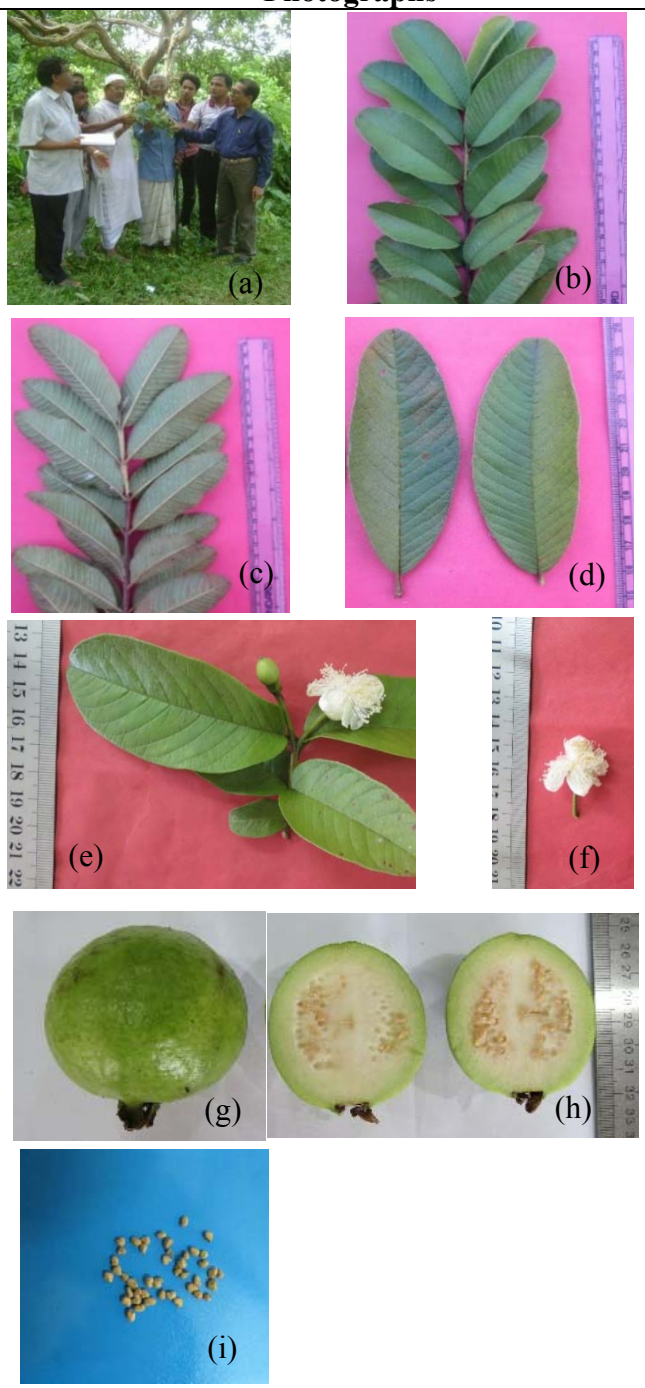
Morphological characterization of Kanchan Nagar Piyara:

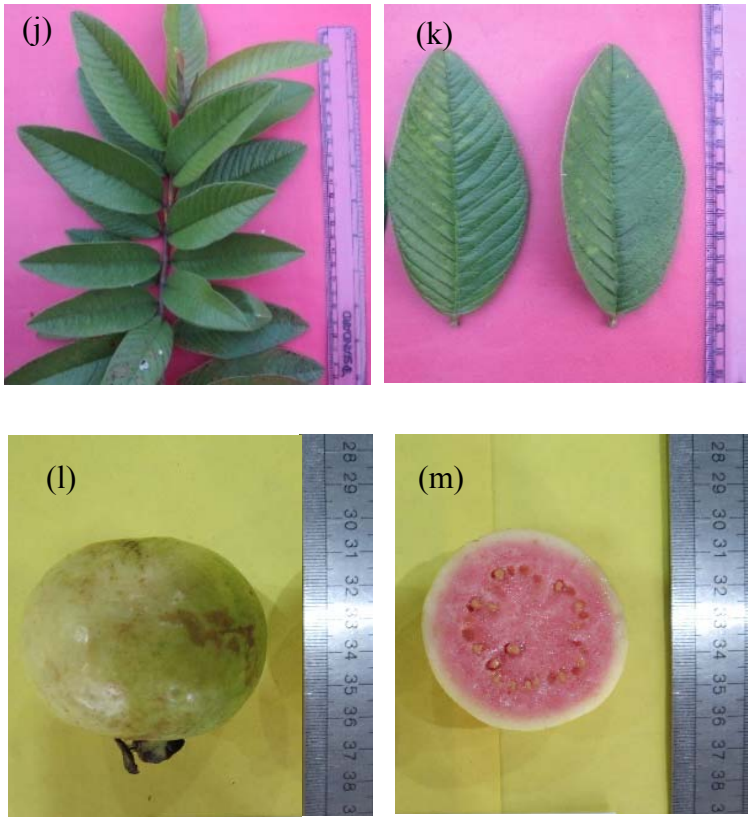
Morphological characters	Photographs
Plant description: Medium to large size plant, height about 5-7m, profuse growth (Fig. 1.2 a). **Stem:** Stems are profusely branched, smooth surface (Fig. 1.2b). **Leaf:** Leaves are medium size, light green color, margin entire, apex blunted/base obtuse, short stalked, dorsal surface smooth, ventral surface rough (Fig. 1.2 b, c, d). **Flower**: Flowers are white color, originated from the leaf axil, petiolated (Fig. 1.2 d), 3-4 sepals green color, 5-6 petals white color, single stigma and numerous anthers. **Fruit**: Fruits are round to pear shape, light green skin, smooth surface, white flesh, texture medium crispy, very sweet taste, total soluble solids 12.86%, less seeded (Fig. 1.2 e, f). **Seeds**: Seeds are small size, brown to dark brown color, medium hard (Fig. 1.2g).	 Fig. 1.2 Morphological characterization of Kanchan Nagar Piyara

A.1.3 Historical background of Mukundapuri Piyara

Mukundapuri piyara is growing commercially in the Bijoynagar Upazilla under Brahmanbaria district of Bangladesh. Local peoples are reported that this variety is growing here from time immemorial. In the past peoples reluctant to eat this guava for the reasons of ignorance. There was a superstition that body temperature rise if they eat the guava specially the red flesh type. Now a days this variety become one of the major varieties especially in the eastern part of Bangladesh.

Morphological characterization of Mukundapuri Piyara:

Morphological characters	Photographs
Plant description: Large size, height about 6-8m and spreading shape (Fig. 1.3a). **Stem:** Stems are branched, smooth surface, round (Fig. 1.3 a). **Leaf:** Leaf length is long (15-16 cm), wider breadth (5-6 cm) entire surface, blunted tip, opposite, overlapping, light green in color, veins are not prominent (Fig. 1.3 b, c, d). **Flower**: Flowers are white in color, calyx 3-4 green color, corolla 4-6 white color, scented and petiolated, originated from leaf axil (Fig. 1.3 e, f). **Fruit:** Fruits are oval shape, golden green color and smooth surface, flesh white, attractive external appearance (Fig. 1.3g, h). Fruit texture crispy to soft, sweet to very sweet, total sugar 7.28%, moisture 83%, vitamin C 87.33 mg/100g flesh, titratable acidity 0.45%. **Seeds:** Seeds are small, rigidity of seed soft at early stage and hard at maturity stage, light brown color (Fig. 1.3 i).	 Fig. 1.3 Morphological characterization of Mukundapuri Piyara

Morphological characters	Photographs
Mukundapuri Piyara (Red flesh) **Plant description:** Large size height about 6-8m and spreading shape. **Stem:** Stems are branched, smooth surface, slightly colored (Fig. 1.3 j). **Leaf:** Leaves are long, entire surface, slightly pointed tip, partially crisscross, green, short petiole (Fig. 1.3 k). **Flower:** Flowers are white in color, calyx are green, corolla are white, scented and petiolated, originated from leaf axil. **Fruit:** Fruits are round shape, smooth surface, pinkish to red color flesh, texture crispy at mature stage but soft at ripe, slightly sour taste, contain less seeds (Fig. 1.3 l, m). **Seed:** Seeds are brown in color, hard at mature stage.	 Fig. 1.3 Morphological characterization of Mukundapuri Piyara

A. 1.4 Historical background of Sayedi Piyara

Many probable places have been searched for Sayedi piyara, but it has already been extinct. However, some data were taken from the plants conserved in the BAU-GPC.

Morphological characterization of Sayedi Piyara:

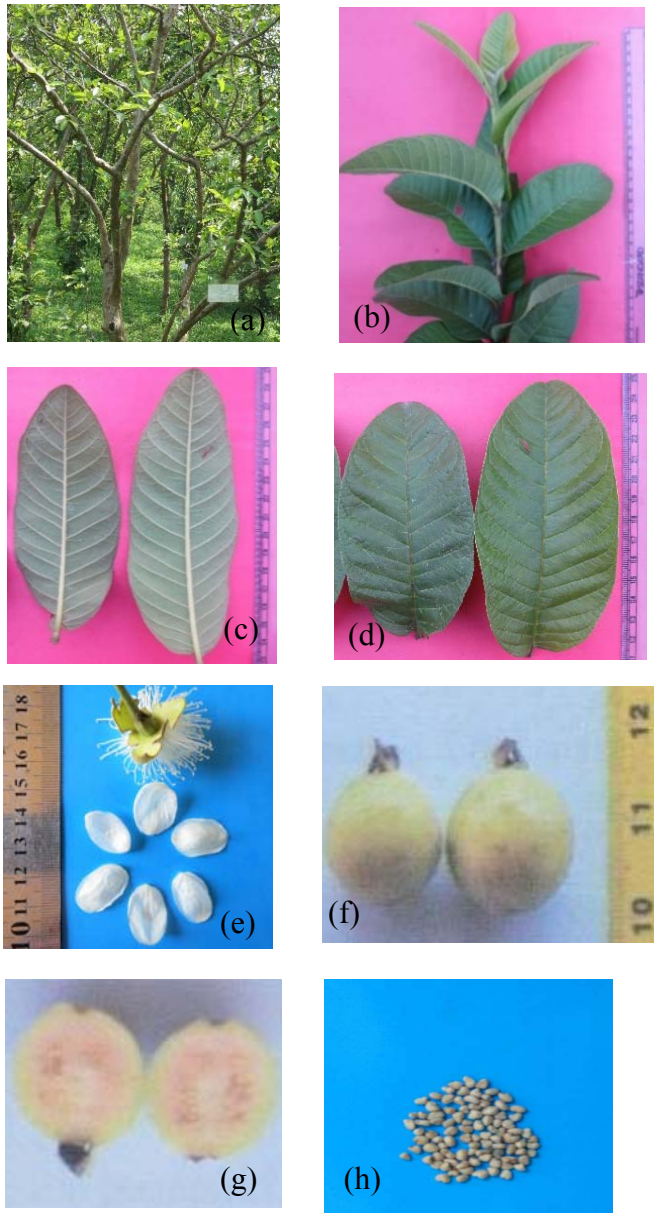
Morphological characters	Photographs
Plant description: Medium size plant, height about 3-4 m, vertically spread and branched (Fig. 1.4a). **Stem:** Stems are branched, smooth in nature, brownish color, round shape (Fig. 1.4 a, b). **Leaf:** Leaves are short, wavy, prominent ribs, opposite but twisted, entire surface, blunted tip, opposite, overlapping, light green in color, veins are not prominent (Fig. 1.4 c, d). **Flower**: Flowers are white in color, calyx 3-4 green color, corolla 6 white color, scented (Fig. 1.4 e). **Fruit**: Fruits are pear shape, moderately smooth surface, light green color, flesh reddish brown or pink, soft texture, sweet taste, total soluble solids 12.76% brix, comparatively less seeded (Fig. 1.4 f, g). **Seeds**: Seeds are brown color, small size, medium hard (Fig. 1.4 h).	 Fig. 1.4 Morphological characterization of Sayedi piyara

Table 7. The distinguished differences among the GI guava varieties

Distinguished characters	GI guava varieties			
	Swarupkanthi	**Kanchan Nagar**	**Mukundapuri**	**Sayedi**
Leaf	Simple leaf, opposite, petiole short, apex semi acute, base obtuse.	Simple, opposite, light green, margin entire, apex blunted/base obtuse, short stalked.	Long, entire surface, blunted tip, opposite, overlapping, light green in color, veins are not prominent	Short, wavy, prominent ribs, opposite but twisted, entire surface, blunted tip, opposite, overlapping, light green in color, veins are not prominent
Fruit Shape	Fruits are globose, round, somewhat rough surface	Round to pear shape, light green skin, smooth surface	Oval, golden green color, smooth surface, attractive appearance	Pear shape, moderately smooth surface, light green color
Fruit quality	Total soluble solids (TSS) 12.93% brix, moisture 86.12%	Total soluble solids (TSS) 12.86%	Total soluble solids (TSS) 7.28%	Total soluble solids 12.76% brix
Flesh color	Creamy white	White	White and reddish pink	Reddish color
Texture	Medium crispy	Medium crispy	Crispy to soft	Soft
Taste	Very sweet	Very sweet	Sweet	Sweet

Molecular characterization of GI Guava:

Molecular characterization of GI guava varieties has been done. Genomic DNA's of Sharupkanthi, Mukundopuri, Kanchan Nagar, Sayedi piyara and BAU piyara 1 were extracted and quantified (Fig. 1). We have selected five primers for RAPD analysis (Table 5). Among the five primers two primers generated various banding pattern. Primer OPA 05 produced 8 bands of which one was polymorphic. Primers OPB07 produced 5 bands of which one was polymorphic.

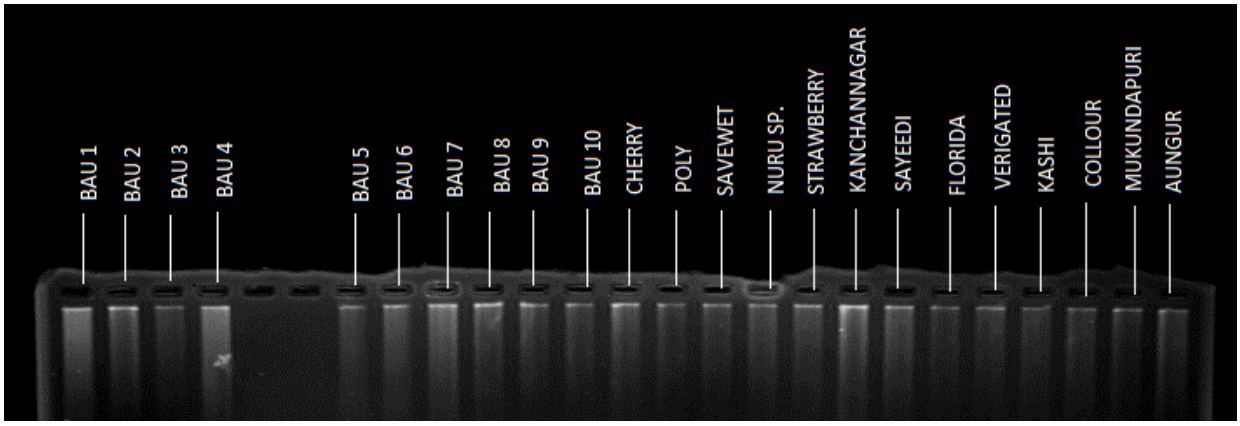


Fig. 1. Extracted genomic DNA of GI guava varieties

A.2 Study on morphological and molecular characterization of GI Jujube (ber/kul)

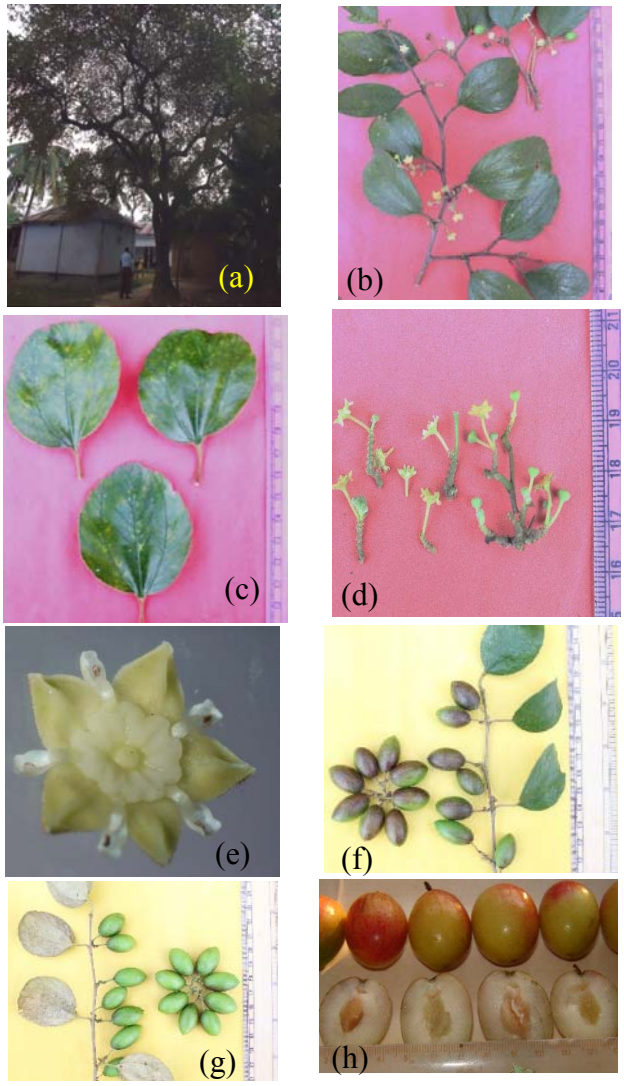
Jujube (ber/kul) is a minor fruit crops in Bangladesh. Now-a-days with the development of improved varieties like BAU-kul, it becomes a major fruit in winter. A number of local, indigenous and GI are growing elsewhere in the country. For example, Apple kul, Zahazi kul. All of these GI varieties are needed to characterize to protect piracy.

A.2.1 Apple kul:

Historical background of Apple kul:

The original apple kul tree was found in the village Chinaduly, Sonargaon block, Torga, Kapashia Upazilla under Gazipur District of Bangladesh. The owner of tree is Mr. Moslehuddin, age about 115 years. As per his statements this kul is being growing in this area from 100 years ago. He has seen many apple kul plants during his childhood. His nick name is tulla, therefore, people in this area called this as tulla kul or Karamcha kul because it looks like karamcha. Apple kul is very popular because of its attractive color and taste. Market demand is very high than all other kul.

Morphological characterization of Apple kul:

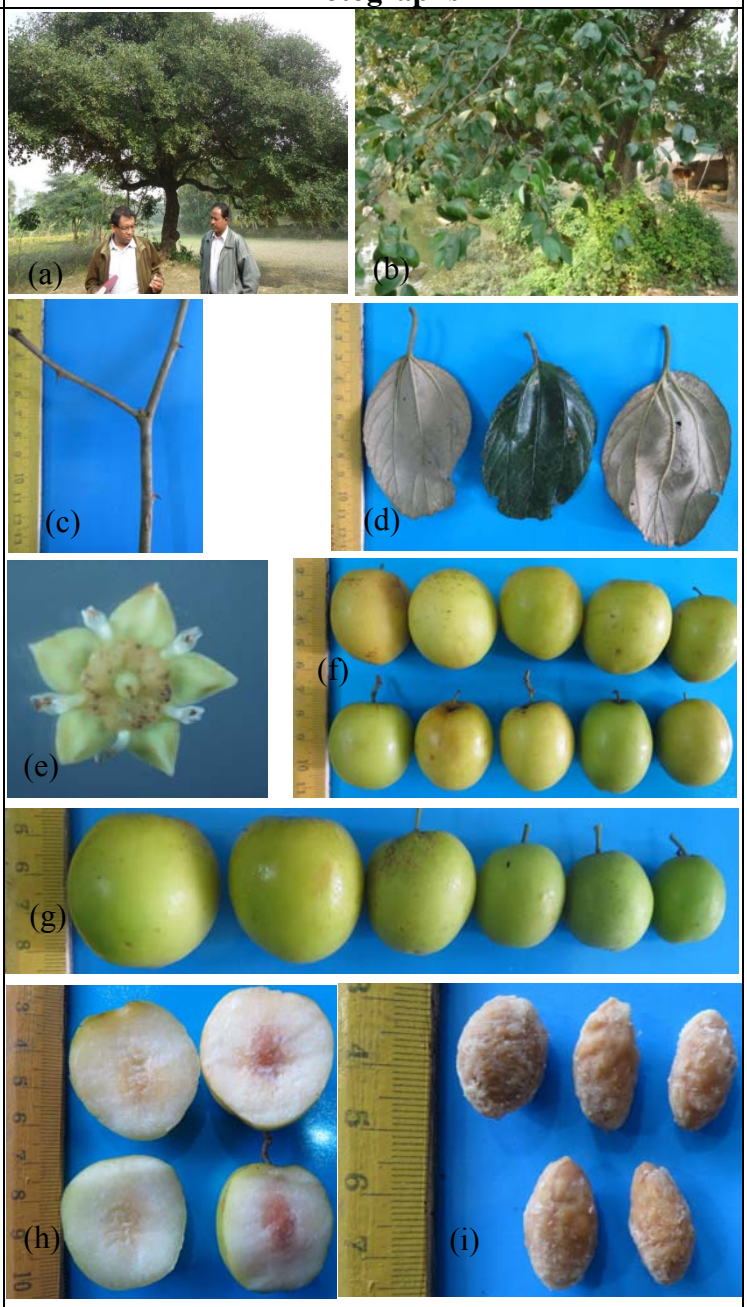
Morphological characters	Photographs
Plant description: Medium to large size tree (8-12 m height), profuse branched (Fig. 2.1a). **Stem:** Stems are spreading, dropping, less spines (Fig. 2.1b). **Leaf:** Oblong, alternate, dark green, glossy, shiny in upper surface and yellowish in lower surface, petiole comparatively long (Fig. 2.1b, c). **Flower:** Flowers are petiolated, blooming in August-September month every year, yellowish color flower, originated in cluster from the leaf axil (Fig. 2.1d, e). **Fruit:** Fruits are medium size, oval to slight elongated shaped, smooth surface, upper part radish and lower part yellowish in color, thin skin, creamy color flesh (Fig. 2.1f, g, h). Average fruit weight, length, diameter & %TSS are 21.12g, 3.4cm, 3.2cm and 19.6%, respectively, **Seeds**: Small to medium size seeds, both ends are slighted pointed, hard shell, rough surface (Fig. 2.1h).	 Fig. 2.1 Morphological characterization of Apple kul

A.2.2 Khacchar kul

Historical background of Khacchar kul:

Khacchar kul was found in Nich Kulihar village of Mandha Upazilla under Nowgaon District of Bangladesh. Information taken from Alhaj Md. Abdul Gani Mollah about 75 years old retired head master of Gobindopur high school. Another person named Md. Latif Mollah (60 years old, Kalopara, Singhi, Gobindapur) also gave us some valuable information about this kul. Khacchar kul is cultivating here more than about 80 years. This kul is more profitable because high price in the market, very tasty & colored than Shabjee kul and Zahazi kul.

Morphological characterization of Khacchar kul:

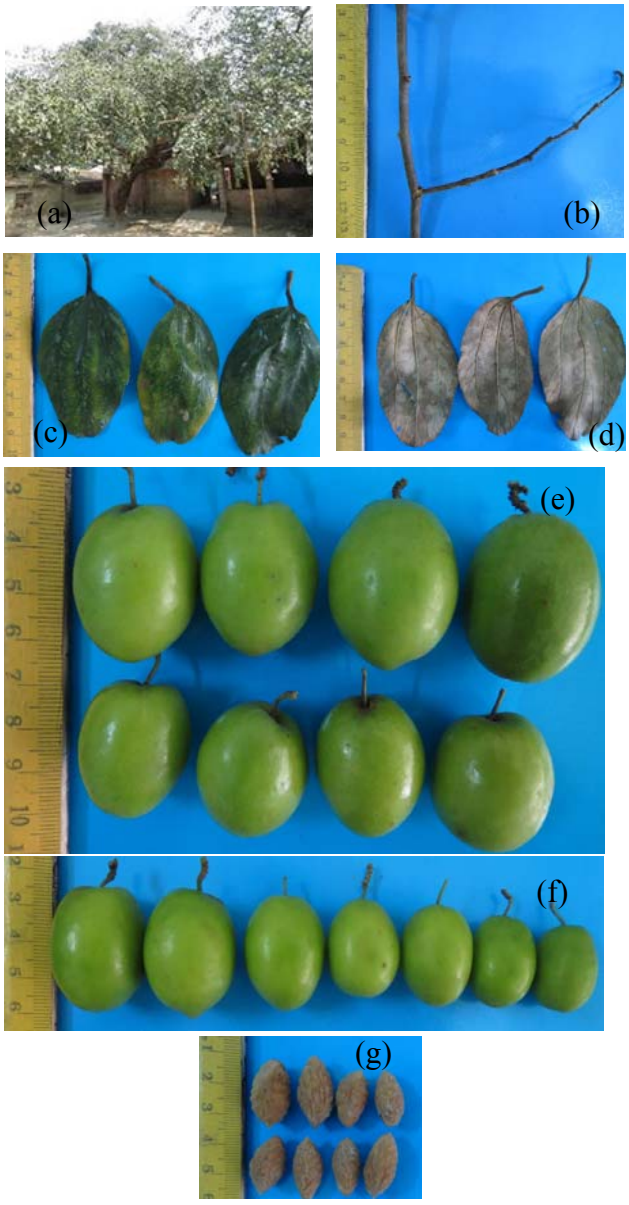
Morphological characters	Photographs
Plant description: Bushy, medium height (6-8m), branched, spreading (Fig. 2.2 a, b). **Stem:** Stem erect, sometime spreading, single spine present in downward motion (Fig. 2.2c). **Leaf:** Rounded to elongated, longer petiole, glabrous on the ventral side, pubescence in the ventral surface. Light green upper side and brown color underneath (Fig. 2.2d). **Flower:** Flowers are creamy white in color, five petals, five calyx (heavy weight), 8 anthers, ovary superior (Fig. 2.2e). **Fruit:** Fruits are round to oblong, crunchy, immature fruits are light green color, ripe fruits are light yellow (Fig. 2.2 f, g, h). Average weight, length, diameter & %TSS are 21.17g, 3.62cm, 3.29cm & 23.78%, respectively. **Seeds:** Seeds are short shaped, slightly pointed, rough surface, comparatively hard (Fig. 2.2i). Average weight, length & diameter are 1.45g, 2.03cm & 1.09 cm, respectively.	 Fig. 2.2 Morphological characterization of Khacchar kul

A.2.3 Shabjee kul

Historical background of Shabjee kul:

Shabjee kul was found in Nich Kulihar village of Mandha Upazilla, Nowgaon Distric of Bangladesh. Information taken from DD, UAO and Md. Abdul Gani Mollah (75 years), Ex Head Master of Gobidapur High School; Md. Latif Mollah (60 years, Kalopara, Singhi, Gobindapur). According to their message Shabjee kul is being cultivating from British Period but now-a-days its cultivation is decreasing due to various disease and pest infestation, excess fruit dropping due to lack natural precipitation during fruiting time. It is a late variety so market price is high. Farmers can earn 16000-20,000 taka per plant.

Morphological characterization of Shabjee kul:

Morphological characters	Photographs
Plant description: Bushy, medium size, height about 5-7m (Fig. 2.3a). **Stem:** Stems are erect type, branched, very less spines on the stem. Some stems are spine less (Fig. 2.3b). **Leaf:** Broad leaf, rounded, long stalked, glabrous on the ventral side, pubescence in the ventral surface. Light green upper side and brown color underneath (Fig. 2.3c, d). **Flower:** Creamy white in color, five petals, five calyx (heavy weight), 8 anthers, ovary superior. **Fruit:** Medium oval to slight elongated, smooth & shiny surface, immature fruits are light green color but greenish yellow color at mature stage, crunchy, thin skin, white flesh (Fig. 2.3e, f).). Average weight, length, diameter & %TSS are 15.79g, 3.11cm, 2.48cm & 15.33%, respectively. **Seeds:** Seeds are small-medium size, pointed in both ends, rough surface, very hard (Fig.2.3g). Average weight, length & diameter are 1.14g, 2.05 cm & 0.84 cm, respectively.	 Fig. 2.3 Morphological characterization of Shabjee kul

A.2.4 Zahazi kul

Histirical background of Zahazi kul:

Zahazi kul was found in Nich Kulihar village of Mandha Upazilla, Nowgaon district of Bangladesh. Information taken from DD, UAO and Md. Abdul Gani Mollah (75 years), Ex Head Master of Gobidapur High School; Md. Latif Mollah (60 years, Kalopara, Singhi, Gobindapur). They told us that Zahazi kul is cultivating in this area from Bristish period. People like this kul very much for its higher yield and good taste. It is comparatively late variety therefore market value high.

Morphological characterization Zahazi kul:

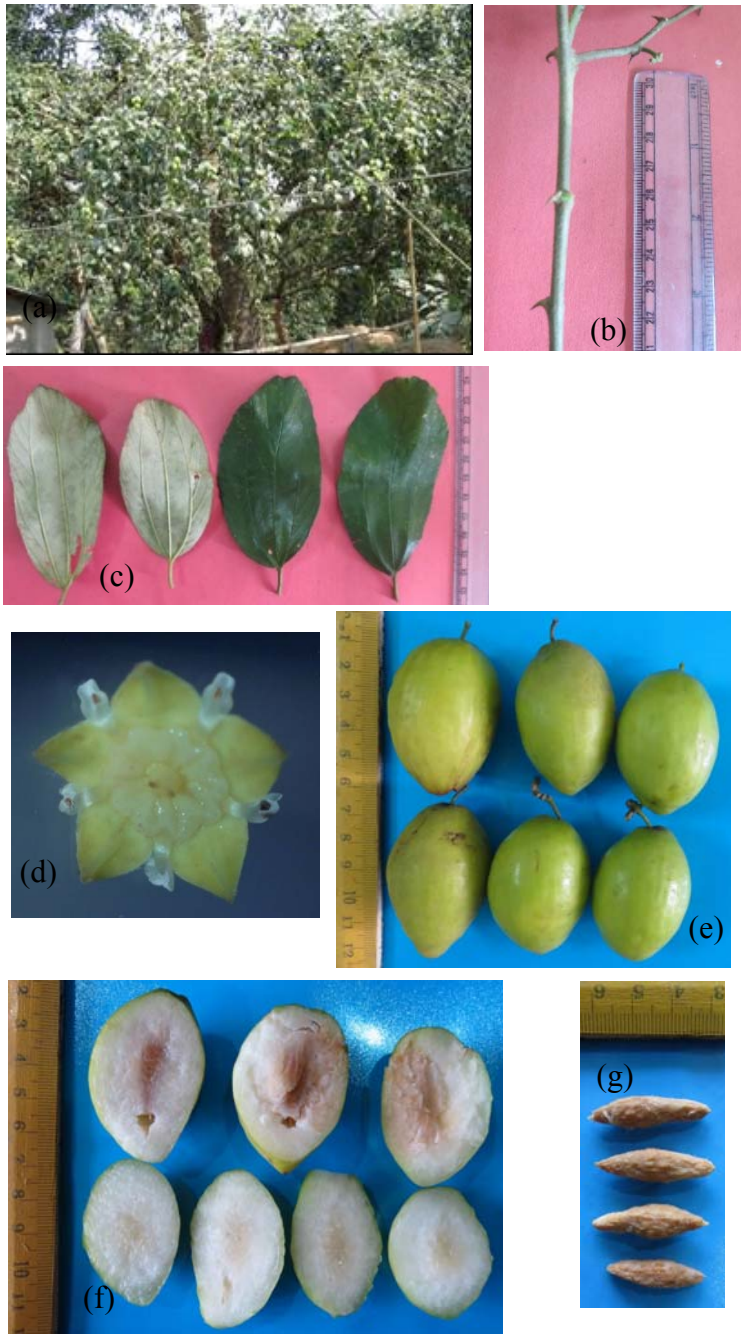
Morphological characters	Photographs
Plant description: Bushy, medium to large height (10-15m), branched, erect type (Fig. 2.4a). **Stem:** Branched, spiny, spines are very hard. Two spines in each node in two direction. One spine upward and other one downward (Fig. 2.4b). **Leaf:** Leaves are elongated type, medium to short stalked, glabrous on the ventral side, pubescence in the ventral surface. Light green upper side and brown color underneath (Fig. 2.4c). **Flower:** Creamy white in color, five petals, five calyx (heavy weight), 8 anthers, ovary superior. **Fruit:** Medium size, oval to oblong, crunchy, immature fruits are light green color, ripe fruits are light yellow, pointed apex, surface smooth & shiny, flesh creamy color, skin thick (Fig. 2.4d, e, f). Average weight, length, diameter & %TSS are 21.78g, 3.84cm, 3.25cm & 21.5%, respectively. **Seeds:** Seeds are short, spindle shape, rough surface, and hard (Fig. 2.4g). Average weight, length & diameter are 1.44g, 2.18 cm & 1.05 cm, respectively.	 Fig. 2.4 Morphological characterization of Zahazi kul

A.2.5 Narikeli kul

Historical background of Narikeli kul:

Narikeli kul is popularly known as kul boroi. It is mainly cultivated in Satkhira, Khulna area of Bangladesh. Most of the old trees has been cut down. However, we got a tree about 90 years old in the Kalaroa Upazilla of Satkhira district. The villagers said this variety is originally growing in this area from the very beginning. Some older people told us that they have seen this kul from their childhood. It is indicated that Satkhira is the origin of Narikeli kul.

Morphological characters of Narikeli kul:

Morphological characters	Photographs
Plant description: Medium size, height about 8-9m, bushy, spreader, drooping branches (Fig. 2.5a). **Stem:** Heavy branched**,** **s**ingle spines are originated from each node. Spines are downward oriented (Fig. 2.5b). **Leaf:** Large elongated, margin curved inside, lower surface white in color, upper side glabrous, obtuse base, short stalked (Fig. 2.5c) **Flower:** Cluster inflorescence arises from the leaf axils and or extraordinary position, flowers are complete, 5 petals creamy white color, 5 stamens (Fig. 2.5d). **Fruit:** Immature fruits are deep green color, odorless, spindle shaped, both end are pointed, greenish yellow al mature stage, smooth surface, very tasty, sweet, thin skin, creamy white flesh (Fig. 2.5e,f). Average fruit weight, length, diameter and %TSS are 23.56 g, 5.05cm, 3.27cm and 21.92%TSS, respectively. **Seeds:** Seeds are elongated, both ends are pointed, hard, rough surface. Average weight, length and diameter are 1.08g, 2.93cm and 0.78cm, respectively (Fig. 2.5g).	 Fig. 2.5 Morphological characterization of Narikeli kul

A.2. 6 Kachua kul

Historical background of Kachua kul:

Kachua kul is cultivated in Kachua Upazilla of Chandpur district of Bangladesh. According to local people information once upon a time this kul was widespread in every villages in Kachua Upazila but it was drastically declined due cultivation of timber tree and also establishment of new houses by removing Kachua kul tree. At present every house has at least one Kachua kul tree. This kul has huge popularity in this area for it good quality and taste. It is a late variety and usually harvesting started at the end of February and beginning of March. The above information was recorded from 90 years old Md. Khalilur Rahman, Village- Palakhal, Kachua, Chandpur.

Morphological characters of Kachua kul:

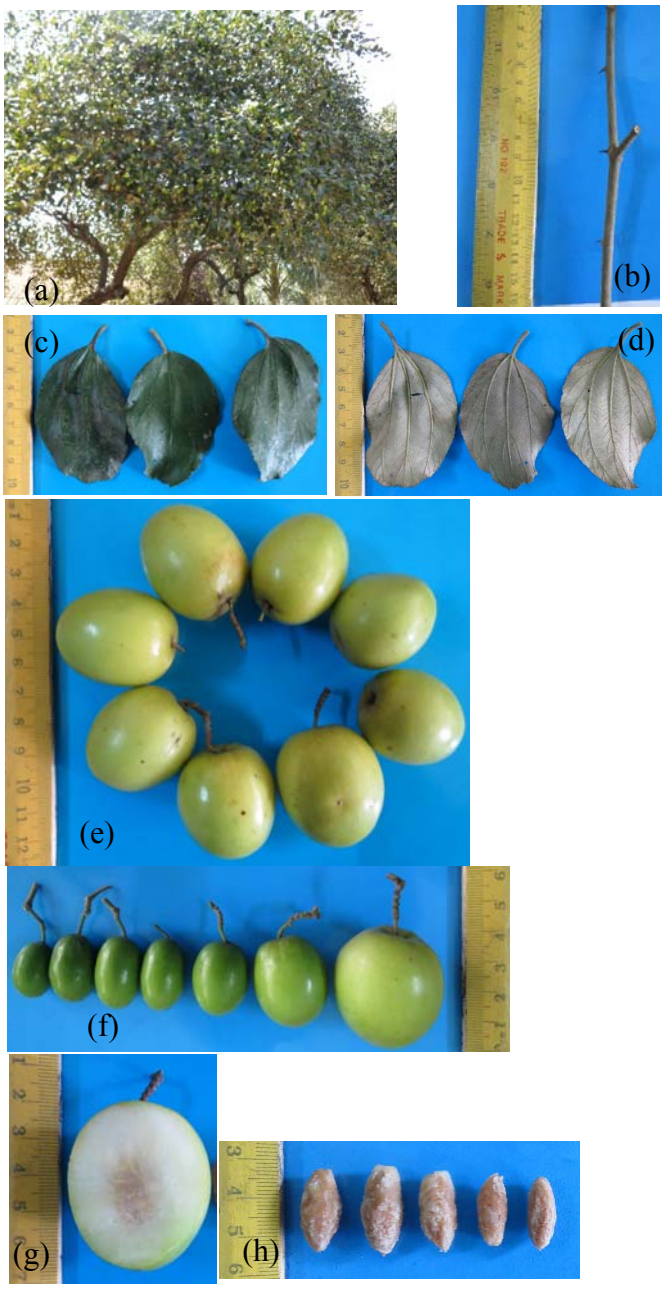
Morphological characters	Photographs
Plant description: Bushy, branched, medium height (8-10m) plant. Braches are drooping in nature (Fig. 2.6a). **Stem:** Main stem is shorter thereafter numerous branching appeared. Single spine is appeared in each node of terminal stems (Fig. 2.6b). **Leaf:** Medium size leaves (8.5-10cm length), elongated, entire margin, brown color lower surface and upper surface smooth green in color, length of leaf petiole is 0.8-1.0cm (Fig. 2.6c, d). **Flower:** Inflorescence are clustered arises from the leaf axils and/or extraordinary position, flowers are complete, 5 petals creamy white color, 5 stamens. **Fruit:** Slightly elongated, roundish fruit top, immature fruits are green color, odorless, both end are pointed, greenish yellow al mature stage (Fig. 2.6e, f, g). Average weight, length, diameter & TSS (%) 22.52 g, 3.72 cm, 3.23 cm & 8.74%, respectively. Smooth surface, very tasty & sweet at ripe stage, thin skin, and white flesh. **Seeds:** Seeds are short elongated, both end partially pointed, hard, rough surface. Average seed weight, length and diameter 1.25 cm, 2.16 cm & 0.93 cm, respectively (Fig. 2.6h).	 Fig. 2.6 Morphological characterization of Kachua kul

Table 8. The distinguished differences among the GI varieties of jujube (ber/kul) are given below:

Distinguished characters		GI jujube (ber/kul) varieties					
		Apple kul	**Khacchar kul**	**Shabjee kul**	**Zahazi kul**	**Narikeli kul**	**Kachua kul**
Leaf		Oblong, alternate, dark green, glossy, shiny in dorsal surface and yellowish in ventral surface, petiole comparatively long.	Rounded, short stalked, glabrous on the dorsal surface, pubescence in the ventral surface. Light green upper side and brown color underneath.	Broad leaf, rounded, long stalked, glabrous on the dorsal side, pubescence in the ventral surface. Light green upper side and brown color underneath.	Rounded, short stalked, glabrous on the dorsal side, pubescence in the ventral surface. Light green upper side and brown color underneath.	Large, elongated, margin curved inward, dorsal side glabrous & ventral surface whitish in color, obtuse base, and short stalked.	Medium size leaves, elongated, entire margin, brown color lower surface and upper surface smooth green in color.
Spine		Two upright spine are originated from each node at early stage of growth but one spine is drop out in advancement of maturity stage.	Single spine, downward motion, hard.	Spines are horizontal to downward facing, originated from each node.	Two spines are originated from each node one is upward and another one is downward facing.	Single spines are originated from each node, downward facing.	Single spines are appeared in each node of terminal stems, horizontal and downward facing.
Fruit	**Shape**	Small oval to slight elongated, smooth surface, upper part radish and lower part yellowish in color.	Round to oblong, crunchy, immature fruits are light green color, ripe fruits are light yellow	Medium oval to slight elongated, smooth & shiny surface, immature fruits are light green color but greenish yellow color at mature stage.	Small to medium oval to oblong, crunchy, immature fruits are light green color, ripe fruits are light yellow, surface smooth & shiny.	Spindle shaped, both end are pointed, greenish yellow color, smooth surface, immature fruits also odorless	Slightly elongated, roundish fruit top, both end are pointed, greenish yellow at mature stage, smooth surface.
	Flesh color	Creamy white	Whitish	White	Creamy white	Creamy white	White
	Texture	Crispy to soft	Medium crispy to soft	Crunchy	Medium crispy	Crispy	Sandy soft
	Taste	Very sweet	Sweet	Medium sweet	Medium sweet	Very sweet	Sweet
	Skin	Thin	Medium thick	Thin	Thick	Thin	Thin

Molecular characterization of GI jujube (ber/kul) varieties using RAPD markers

Molecular markers provide a quick and reliable method for estimating genetic relationships among genotypes of any organism. They can facilitate rapid screening of large number of genotypes for polymorphic loci. Among the molecular markers, RAPD analysis is simple, fast and easy to perform among the DNA-based techniques for use in genetic similarity studies. The advantages of RAPDs over other DNA-based methods include a lack of the requirement for sequence information of the species, ease and speed of the assay, little amount of DNA required, no use of radioactivity and ability to provide markers in genomic regions with repetitive DNA sequences. Hence, the present investigation was carried out for analyzing the amount of genetic variation in ber accessions and classifying them to assist in selection of parent in breeding program. The results obtained from the experiment have been presented and discussed under the following headings.

Table 9. RAPD primers with corresponding bands score range together with polymorphic bands observed in 14 jujube genotypes

Primer code	Total number of fragments scored	Number of polymorphic loci
OPC 15	9	4
OPD 03	13	4
OPF 02	8	4
OPF 03	12	7
OPF 11	7	2
Total	49	21
% polymorphic loci		42.42

Polymorphisms in 14 jujube accessions detected by RAPD

Five decamer primers were used in RAPD analysis of 14 jujube genotypes, which gave 49 consistent and differential amplification products and, were included in the analysis. The number of bands per primer varied from 7 to 13 scorable fragments, and was amplified with an average of 9.8 bands per primer. Among them, 21 bands (42.42%) were polymorphic and the remaining was found to be monomorphic, i.e. they were present in all the accessions. The DNA polymorphism as revealed by five of the highly polymorphic primers, is depicted in Fig. 2 to 6.

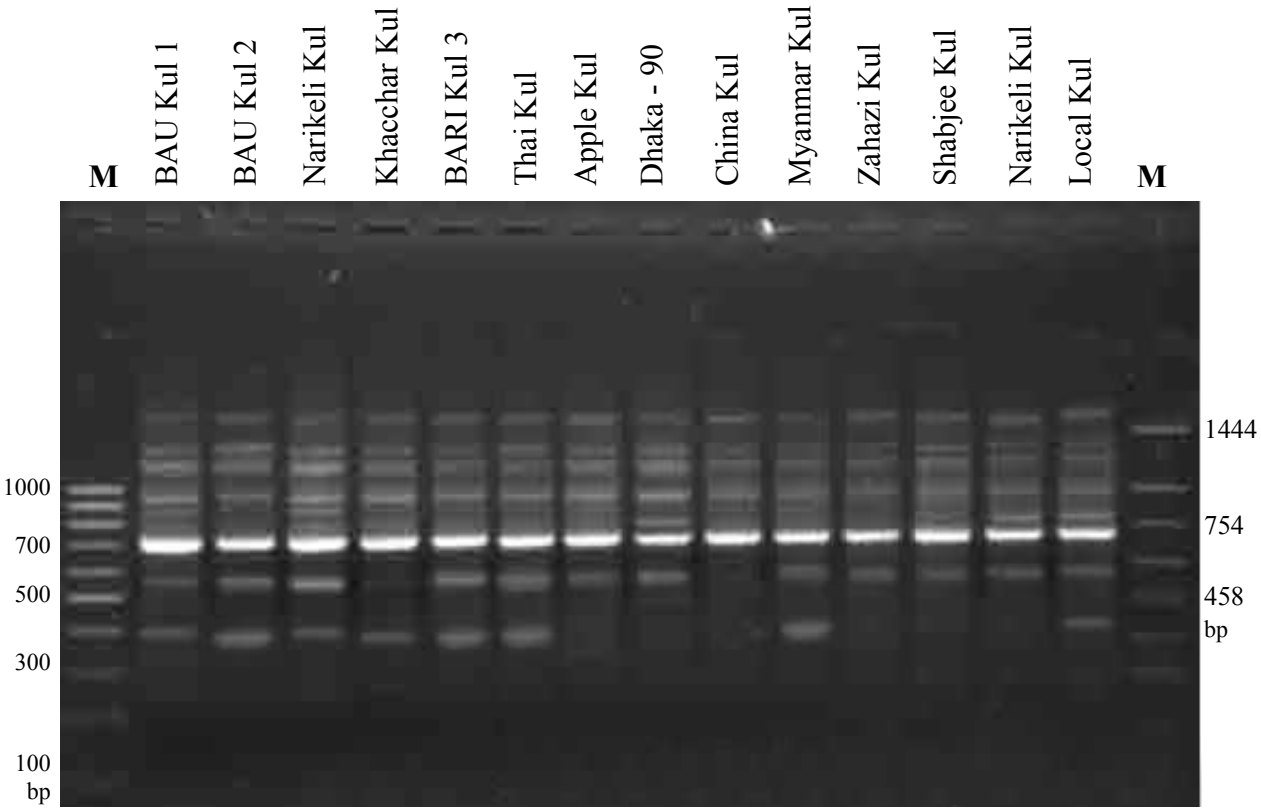


Fig. 2. RAPD profile of 14 jujube genotypes using primer OPC 15. M: Molecular weight marker (100 bp DNA ladder in left side and pUC 18/saU 3Al-pUC 18/Taq Digest in right side)

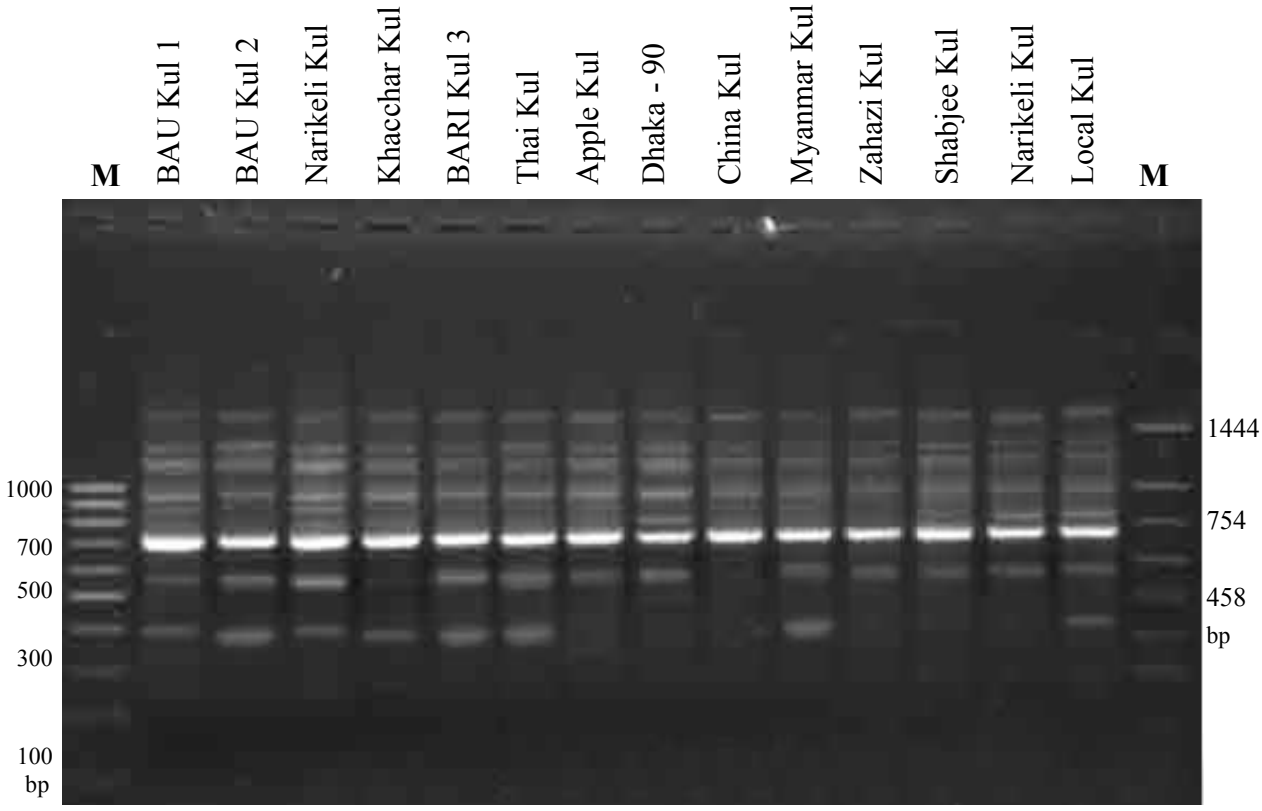


Fig. 3. RAPD profile of 14 jujube genotypes using primer OPD 03. M: Molecular weight marker (100 bp DNA ladder in left side and pUC 18/saU 3Al-pUC 18/Taq Digest in right side).

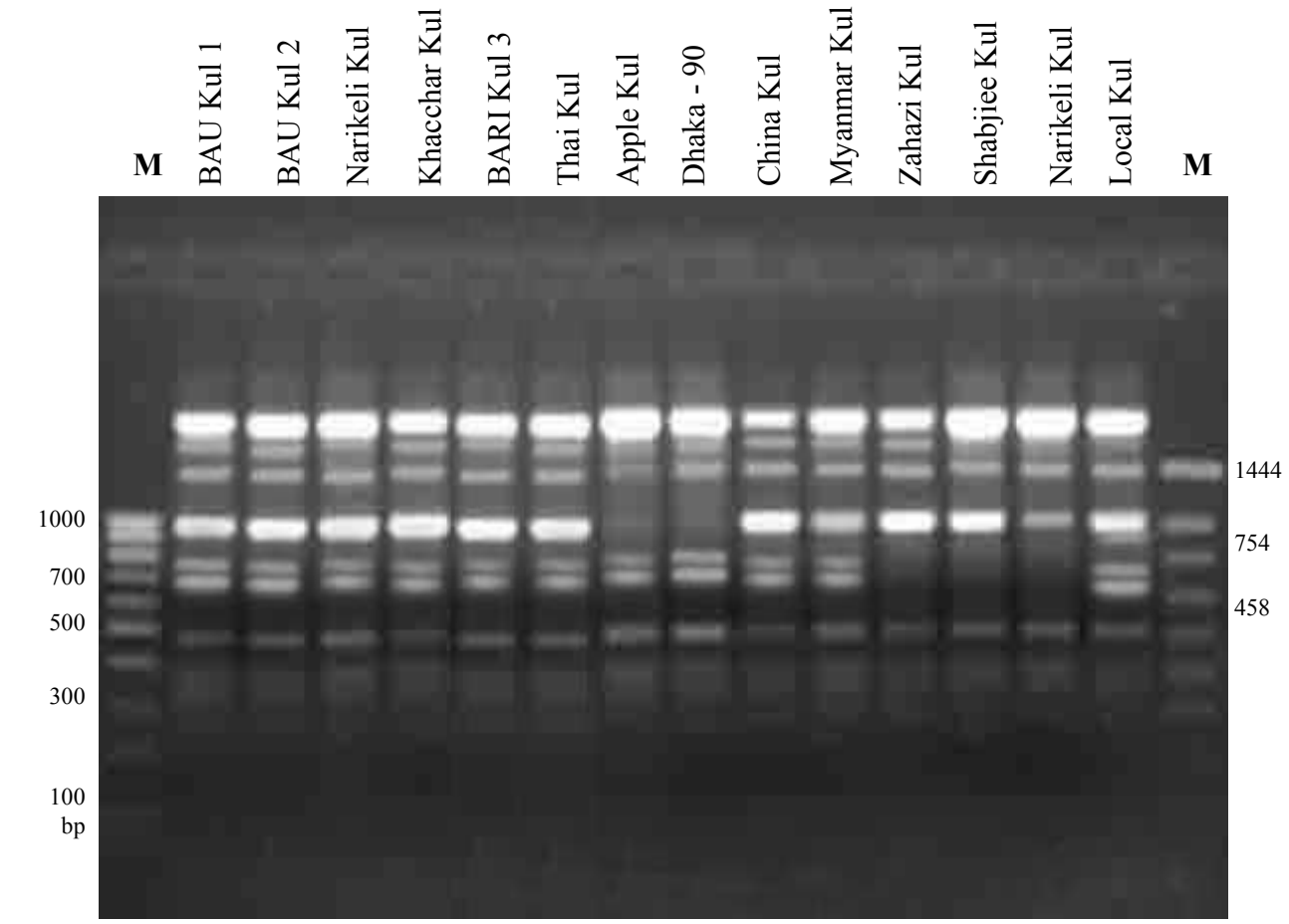


Fig. 4. RAPD profile of 14 jujube genotypes using primer OPF 02. M: Molecular weight marker (100 bp DNA ladder in left side and pUC 18/saU 3Al-pUC 18/Taq Digest in right side).

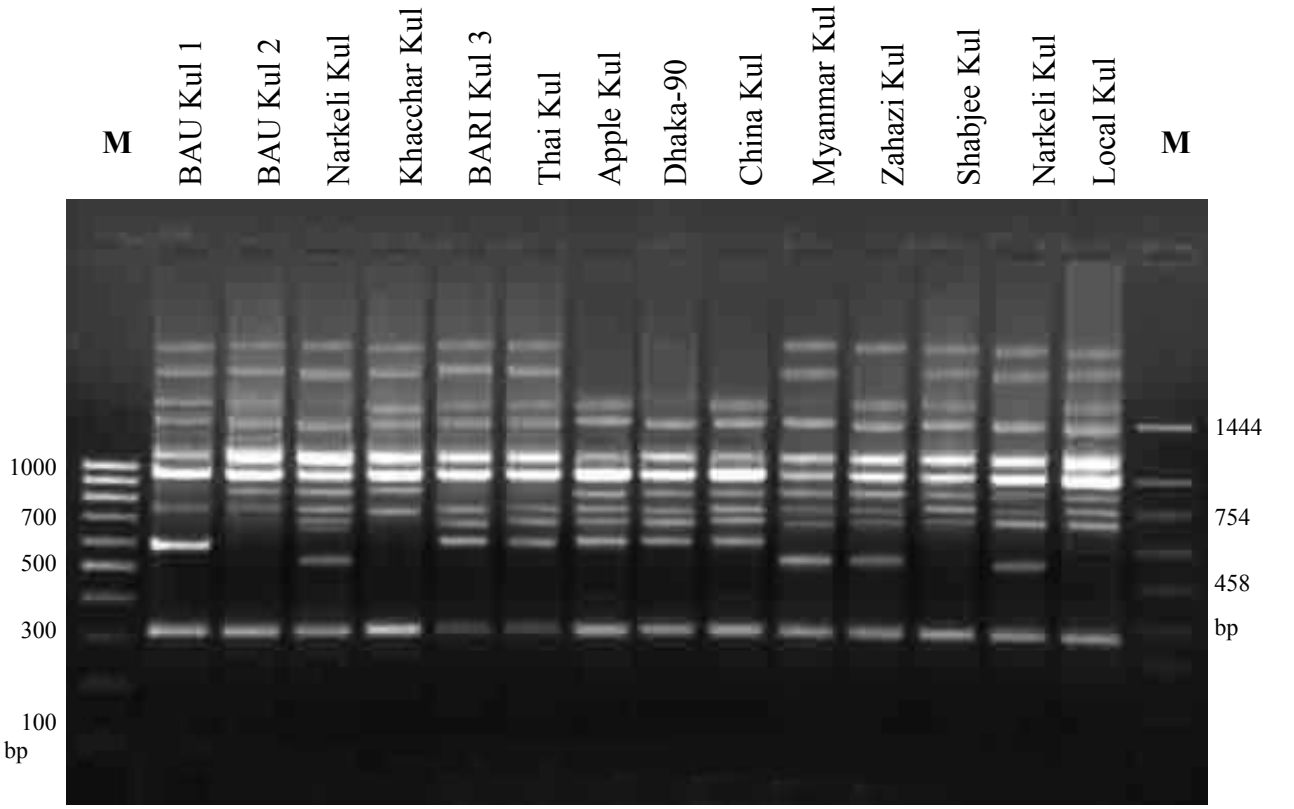


Fig. 5. RAPD profile of 14 jujube genotypes using primer OPF 03. M: Molecular weight marker (100 bp DNA ladder in left side and pUC 18/saU 3Al-pUC 18/Taq Digest in right side).

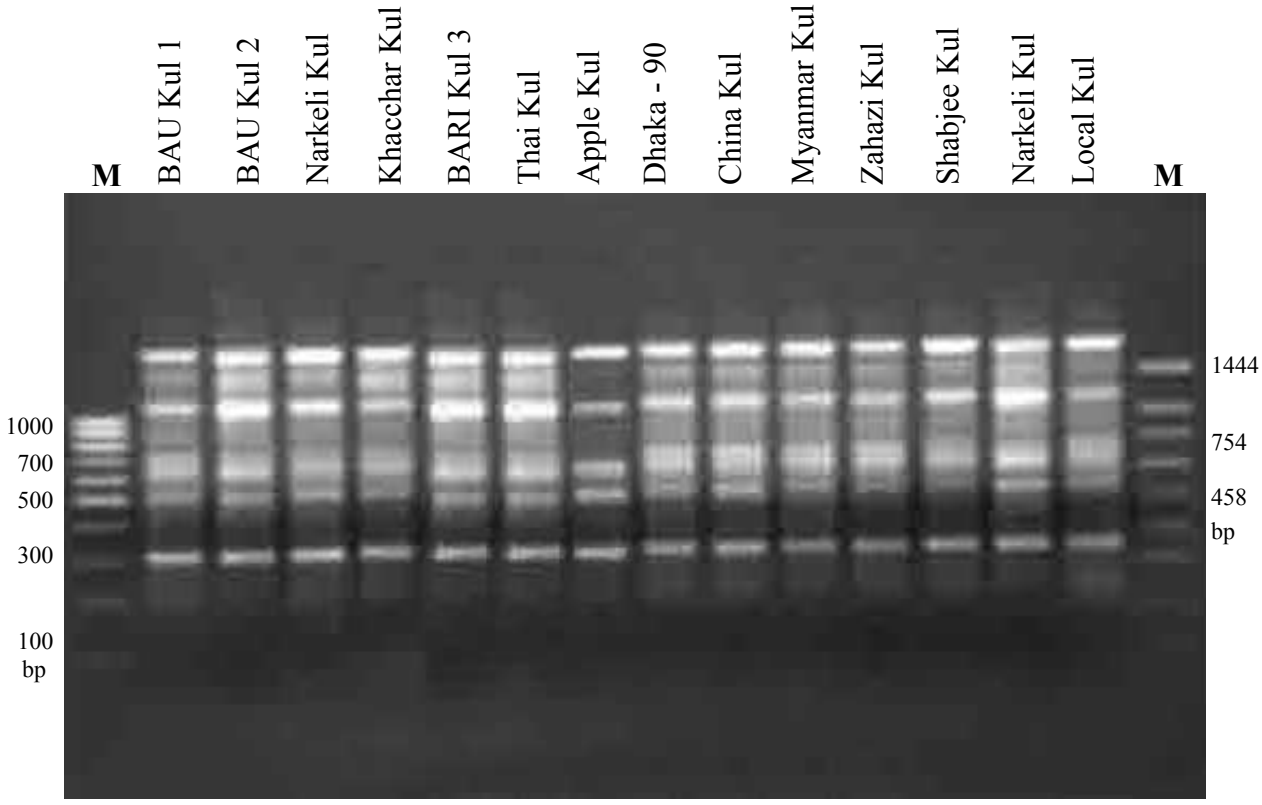


Fig. 6. RAPD profile of 14 jujube genotypes using primer OPF 11. M: Molecular weight marker (100 bp DNA ladder in left side and pUC 18/saU 3Al-pUC 18/Taq Digest in right side).

The dendrogram based on genetic distance using unweighted Pair Group Method of Arithmetic Means (UPGMA) revealed segregation of the 14 jujube accessions into four clusters(Fig. 7). The constructed dendrogram clearly discriminated the different genotypes of jujube used in this experiment. The cluster I included the highest number of genotypes (5) collected from different geographical locations. The rest of the cluster was contained 3 genotypes. Divergent genotypes may have good breeding value. Genotypes in the same cluster may represent members of one heterotic group. The maximum variability for selection from segregation populations may be achieved by utilizing genotypes from different clusters as parents of crosses.

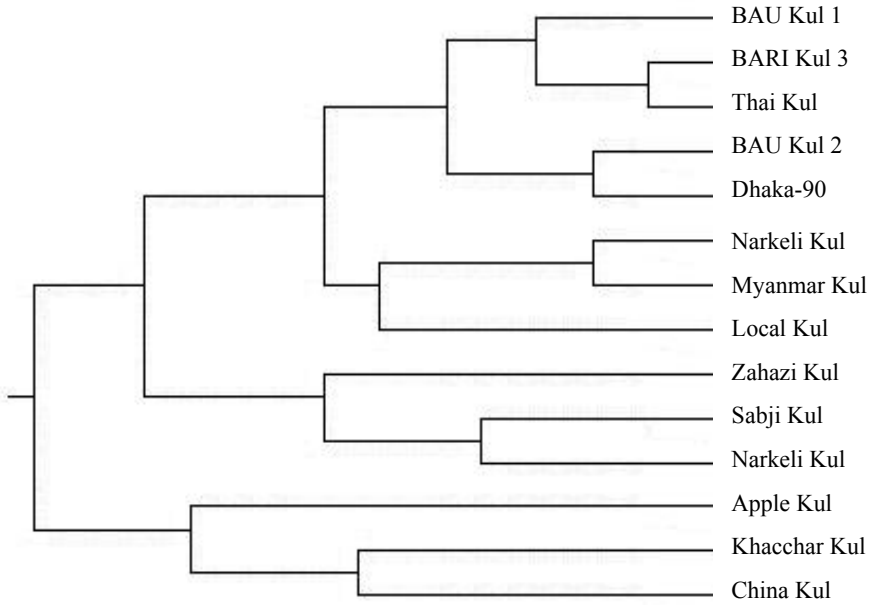


Fig. 7. Unweighted pair group method of arithmetic mean (UPGMA) dendrogram based on Nei's (1972) genetic distance, summarizing data on differentiation in 14 ber genotypes according to RAPD analysis.

B) Characterization of BAU-GPC released mango varieties:

Although GI mango varieties has not been included for BAU-part. Varieties developed by BAU-GPC has been characterized. The BAU-GPC conserved 287 germplasm of mango since 1991 from which BAU-GPC has registered 17 varieties of mango. The morphological features of those varieties are given blow:

Morphological characters of BAU Aam-1

Parameters	Units	Photographs
Age of plant	5 years	
Height	2.00 m	
Canopy spreading (N-S)	2.1 m	
Canopy spreading (E-W)	2.8 m	
Base girth	31.66 cm	
Leaf blade shape	Eliptic	
Leaf blade length	23.84 cm	
Leaf blade width	7.64 cm	
Petiole length	3.62 cm	
Leaf apex shape	Acute	
Leaf base shape	Acute	
Leaf margin	Entire	
Colour of young leaf	Pinkish	
Colour of fully developed leaf	Green	
Regularity of flowering	Regular	
Inflorescence position	Terminal & axillary	
Inflorescence shape	Conical	
Inflorescence length	41.72 cm	
Inflorescence width	23.32 cm	
Presence of leafy bracts	Present	
Type of flower	Pentamerous	
Fruit weight	280.33 g	
Fruit length	9.44 cm	
Fruit width	7.56 cm	
Fruit thickness	6.77 cm	
Volume of fruit	260.33 CC	
Fruit shape	Roundish	
Shape of fruit apex	Obtuse	
Skin colour of ripe fruit	Yellow	
Depth of fruit stalk cavity	Absent	
Fruit neck prominence	Absent	
Slope of fruit ventral shoulder	Raising and then rounded	
Fruit beak type	Pointed	
Fruit sinus type	Shallow	
Fruit skin waxiness	Waxy	
Skin surface texture	Smooth	
Weight of skin	42.66 g	
Skin thickness	0.13 cm	
Pulp colour	Yellow orange	

Fig. Morphological characterization of BAU Aam-1

Parameters	Units	Photographs
Pulp texture	Intermediate	
Adherence of fruit skin to pulp	Intermediate	
Quantity of fiber in pulp	Intermediate	
Fiber length in the pulp	Short	
Pulp content	202.33 g	
Stone length	7.34 cm	
Stone width	4.22 cm	
Stone thickness	2.26 cm	
Stone weight	43.33 g	
Veins on stone	Elevated	
Quantity of fiber on stone	Intermediate	
Seed length	7.16 cm	
Seed width	3.36 cm	
Seed weight	37.66 g	
Seed shape	Ellipsoid	
Type of embryony	Monoembryony	
TSS (%)	18.43	
pH	4.96	
Titratable acid (%)	0.128	
Vit C content (mg/100g)	2.70	
%RS	3.30	
%NRS	6.13	
%TS	9.43	
β-Carotene (µg/100g)	59.10	
% MC	84.26	

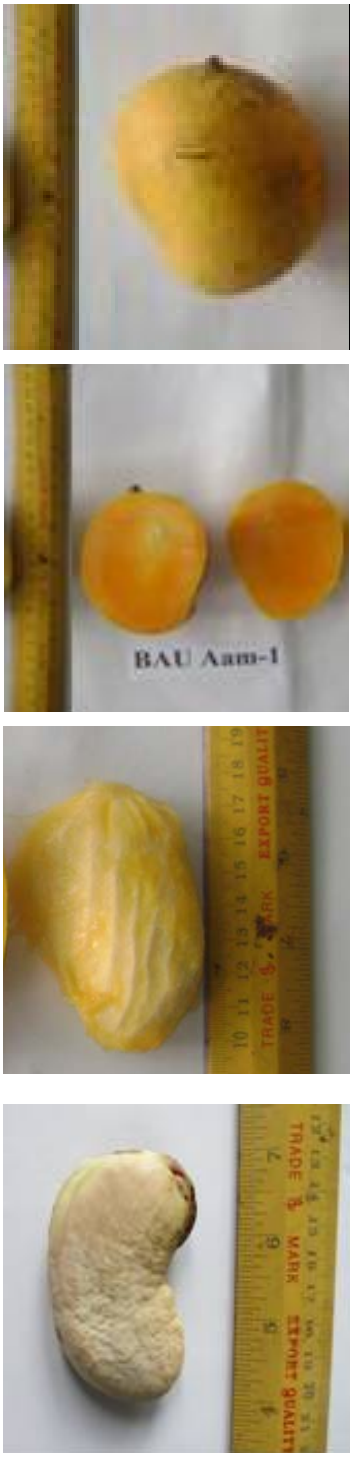


Fig. Morphological characterization of BAU Aam-1

Morphological characters of BAU Aam-2

Parameters	Units	Photographs
Age of plant	5 years	
Height	217.33 cm	
Canopy spreading (N-S)	1.61 m	
Canopy spreading (E-W)	1.97 m	
Base girth	34.66 cm	
Leaf blade shape	Lanceolate	
Leaf blade length	23.88 cm	
Leaf blade width	5.26 cm	
Petiole length	4.40 cm	
Leaf apex shape	Acuminate	
Leaf base shape	Acute	
Leaf margin	Wavy	
Colour of fully developed leaf	Green	
Regularity of flowering	Regular	
Inflorescence position	Terminal	
Inflorescence shape	Conical	
Inflorescence length	35.06 cm	
Inflorescence width	20.48 cm	
Presence of leafy bracts	Absent	
Type of flower	Pentamerous	
Fruit weight	143.00 g	
Fruit length	7.54 cm	
Fruit width	6.17 cm	
Fruit thickness	5.69 cm	
Volume of fruit	122.00 CC	
Fruit shape	Obovoid	
Shape of fruit apex	Obtuse	
Skin colour of ripe fruit	Purple blotch with yellow	
Depth of fruit stalk cavity	Shallow	
Fruit neck prominence	Absent	
Slope of fruit ventral shoulder	Ending in a long curve	
Fruit beak type	Perceptible	
Fruit sinus type	Absent	
Fruit skin waxiness	Waxy	
Skin surface texture	Smooth	
Weight of skin	19.33 g	
Skin thickness	0.15 cm	
Pulp colour	Yellow orange	
Pulp texture	Intermediate	
Adherence of fruit skin to pulp	Intermediate	
Quantity of fiber in pulp	Absent	
Pulp content	112.00 g	
Stone length	5.89 cm	
Stone width	3.47 cm	
Stone thickness	1.33 cm	
Stone weight	13.66 g	
Veins on stone	Elevated	
Quantity of fiber on stone	Low	
Seed length	4.41 cm	
Seed width	2.96 cm	

Fig. Morphological characterization of BAU Aam-2

Parameters	Units	Photographs
Seed weight	7.5 g	
Seed shape	Oblong	
Type of embryony	Monoembryony	
TSS (%)	19.66	
pH	3.64	
Titratable acid (%)	1.024	
Vit C content (mg/100g)	29.70	
%RS	4.63	
%NRS	6.68	
%TS	11.31	
β-Carotene (µg/100g)	56.71	
% MC	79.42	

Fig. Morphological characterization of BAU Aam-2

Morphological characters of BAU Aam-3

Parameters	Units	Photographs
Age of plant	5years	
Height	262.66 cm	
Canopy spreading (N-S)	253.33 cm	
Canopy spreading (E-W)	248.66 cm	
Base girth	39.00 cm	
Leaf blade shape	Lanceolate	
Leaf blade length	23.66 cm	
Leaf blade width	5.28 cm	
Petiole length	5.66 cm	
Leaf apex shape	Acuminate	
Leaf base shape	Acute	
Leaf margin	Entire	
Colour of young leaf	Pinkish	
Colour of fully developed leaf	Green	
Regularity of flowering	Regular	
Inflorescence position	Terminal & axillary	
Inflorescence shape	Pyramidal	
Inflorescence length	35.40 cm	
Inflorescence width	26.64 cm	
Inflorescence colour		
Presence of leafy bracts	Absent	
Type of flower	Pentamerous	
Fruit weight	347.00 g	
Fruit length	10.84 cm	
Fruit width	7.90 cm	
Fruit thickness	6.64 cm	
Volume of fruit	335.66 CC	
Fruit shape	El[ptic	
Shape of fruit apex	Obtuse	
Skin colour of ripe fruit	Greenish yellow	
Depth of fruit stalk cavity	Absent	
Fruit neck prominence	Absent	
Slope of fruit ventral shoulder	Ending in along curve	
Fruit beak type	Perceptible	
Fruit sinus type	Absent	
Fruit skin waxiness	Waxy	
Skin surface texture	Smooth	
Weight of skin	46.33 cm	
Skin thickness	0.15 cm	
Pulp colour	Yellow orange	
Pulp texture	Firm	
Adherence of fruit skin to pulp	Intermediate	
Quantity of fiber in pulp	Intermediate	

Fig. Morphological characterization of BAU Aam-3

Parameters	Units	Photographs
Fiber length in the pulp	Long	
Pulp content	244.33 g	
Stone length	9.36 cm	
Stone width	5.03 cm	
Stone thickness	2.04 cm	
Stone weight	56.33 g	
Quantity of fiber on stone	Intermediate	
Seed length	6.45 cm	
Seed width	3.17 cm	
Seed weight	21.5 g	
Seed shape	Reniform	
Type of embryony	Monoembryony	
TSS (%)	14.73	
pH	3.60	
Titratable acid (%)	0.704	
Vit C content	6.30	
%RS	2.28	
%NRS	5.06	
%TS	7.34	
β-Carotene (µg/100g)	34.70	
% MC	86.33	
		Fig. Morphological characterization of BAU Aam-3

Morphological characters of BAU Aam-4

Parameters	Units	Photographs
Age of plant	5years	
Height	251.66 cm	
Canopy spreading (N-S)	210.00 cm	
Canopy spreading (E-W)	227.33 cm	
Base girth	33.33 cm	
Leaf blade shape	Oblong	
Leaf blade length	19.72 cm	
Leaf blade width	5.24 cm	
Petiole length	3.14 cm	
Leaf apex shape	Acuminate	
Leaf base shape	Obtuse	
Leaf margin	Wavy	
Colour of young leaf		
Colour of fully developed leaf	Dark green	
Regularity of flowering	Regular	
Inflorescence position	Terminal	
Inflorescence shape	Pyramidal	
Inflorescence length	35.40 cm	
Inflorescence width	19.92 cm	
Presence of leafy bracts	Absent	
Type of flower	Pentamerous	
Fruit weight	289.33 g	
Fruit length	12.36 cm	
Fruit width	6.72 cm	
Fruit thickness	6.07 cm	
Volume of fruit	237.33 CC	
Fruit shape	Oblong	
Shape of fruit apex	Acute	
Skin colour of ripe fruit	Yellow	
Depth of fruit stalk cavity	Absent	
Fruit neck prominence	Slightly prominent	
Slope of fruit ventral shoulder	Slopping abruptly	
Fruit beak type	Mammiform	
Fruit sinus type	Absent	
Fruit skin waxiness	Waxy	
Skin surface texture	Smooth	
Weight of skin	27.33 cm	
Skin thickness	0.10 cm	
Pulp colour	Yellow	
Pulp texture	Soft	
Adherence of fruit skin to pulp	Weak	
Quantity of fiber in pulp	Absent	
Pulp content	238.33 g	
Stone length	10.24 cm	
Stone width	3.67 cm	
Stone thickness	1.33 cm	

Fig. Morphological characterization of BAU Aam-4

Parameters	Units	Photographs
Stone weight	23.66 g	
Quantity of fiber on stone	Low	
Seed length	5.05 cm	
Seed width	2.04 cm	
Seed weight	7.66 g	
Seed shape	Ellipsoid	
Type of embryony	Monoembryony	
TSS (%)	22.50	
pH	4.75	
Titratable acid (%)	0.192	
Vit C content (mg/100g)	2.70	
%RS	5.15	
%NRS	10.94	
%TS	16.09	
β-Carotene (µg/100g)	50.62	
% MC	76.99	

Fig. Morphological characterization of BAU Aam-4

Morphological characters of BAU Aam-5

Parameters	Units	Photographs
Age of plant	5years	
Height	221.66 cm	
Canopy spreading (N-S)	231.66 cm	
Canopy spreading (E-W)	166.00 cm	
Base girth	35.13 cm	
Leaf blade shape	Eliptic	
Leaf blade length	21.36 cm	
Leaf blade width	5.86 cm	
Petiole length	2.96 cm	
Leaf apex shape	Acute	
Leaf base shape	Acute	
Leaf margin	Entire	
Colour of young leaf	Pinkish	
Colour of fully developed leaf	Green	
Regularity of flowering	Regular	
Inflorescence position	Terminal &axillary	
Inflorescence shape	Conical	
Inflorescence length	41.04 cm	
Inflorescence width	26.60 cm	
Presence of leafy bracts	Absent	
Type of flower	Pentamerous	
Fruit weight	283.00 g	
Fruit length	9.41 cm	
Fruit width	7.62 cm	
Fruit thickness	6.60 cm	
Volume of fruit	256.00 CC	
Fruit shape	Roundish	
Shape of fruit apex	Obtuse	
Skin colour of ripe fruit	Yellow	
Depth of fruit stalk cavity	Absent	
Fruit neck prominence	Absent	
Slope of fruit ventral shoulder	Rising and then rounded	
Fruit beak type	Pointed	
Fruit sinus type	Shallow	
Fruit skin waxiness	Waxy	
Skin surface texture	Smooth	
Weight of skin	41.00 cm	
Skin thickness	0.12 cm	
Pulp colour	Yellow orange	
Pulp texture	Intermediate	
Adherence of fruit skin to pulp	Intermediate	Fig. Morphological characterization of BAU Aam-5
Quantity of fiber in pulp	Intermediate	
Fiber length in the pulp	Long	
Pulp content	207.00 g	
Stone length	7.15 cm	
Stone width	4.20 cm	

Parameters	Units	Photographs
Stone thickness	1.83 cm	
Stone weight	35.00 g	
Veins on stone	Elevated	
Quantity of fibre on stone	Intermediate	
Seed length	6.86 cm	
Seed width	3.29 cm	
Seed weight	33.66 g	
Seed shape	Ellipsoid	
Type of embryony	Monoembryony	
TSS (%)	17.63	
pH	4.40	
Titratable acid (%)	0.182	
Vit C content (mg/100g)	4.50	
%RS	2.87	
%NRS	7.98	
%TS	7.98	
β-Carotene (µg/100g)	48.21	
% MC	87.01	

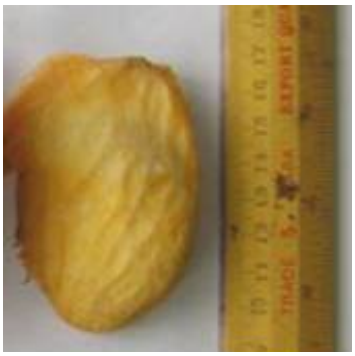


Fig. Morphological characterization of BAU Aam-5

Morphological characters of BAU Aam-6

Parameters	Units	Photographs
Age of plant	5 years	
Height	312.00 cm	
Canopy spreading (N-S)	309.00 cm	
Canopy spreading (E-W)	336.00 cm	
Base girth	45.36 cm	
Leaf blade shape	Oblong	
Leaf blade length	19.18 cm	
Leaf blade width	5.78 cm	
Petiole length	4.12 cm	
Leaf apex shape	Acute	
Leaf base shape	Obtuse	
Leaf margin	Wavy	
Colour of young leaf		
Colour of fully developed leaf	Green	
Regularity of flowering	Regular	
Inflorescence shape	Broadly pyramidal	
Inflorescence length	34.92 cm	
Inflorescence width	25.46	
Inflorescence colour		
Presence of leafy bracts		
Fruit weight	388.66 g	
Fruit length	11.31 cm	
Fruit width	7.61 cm	
Fruit thickness	7.45 cm	
Volume of fruit	344.00 cm	
Fruit shape	Eliptic	
Shape of fruit apex	Obtuse	
Skin colour of ripe fruit	Yellow	
Depth of fruit stalk cavity	Absent	
Fruit neck prominence	Slightly prominent	
Slope of fruit ventral shoulder	Slopping abruptly	
Fruit beak type	Perceptible	
Fruit sinus type	Absent	
Fruit skin waxiness	Waxy	
Skin surface texture	Rough	
Weight of skin	71.00 g	
Skin thickness	0.16 cm	
Pulp colour	Orange	
Pulp texture	Intermediate	
Adherence of fruit skin to pulp	Intermediate	
Quantity of fiber in pulp	Medium	
Fiber length in the pulp	Medium	
Pulp content	280.33 g	
Stone length	9.45 cm	
Stone width	3.91 cm	
Stone thickness	1.89 cm	

Fig. Morphological characterization of BAU Aam-6

Parameters	Units	Photographs
Stone weight	37.33 g	
Veins on stone	Prominent	
Quantity of fiber on stone	Medium	
Seed length	6.69 cm	
Seed width	2.93 cm	
Seed weight	22.5 g	
Seed shape	Ellipsoid	
Type of embryony	Poly embryony	
TSS (%)	21.83	
pH	4.10	
Titratable acid (%)	0.67	
Vit C content (mg/100g)	4.50	
%RS	7.14	
%NRS	5.05	
%TS	12.19	
β-Carotene (µg/100g)	32.69	
% MC	80.05	

Fig. Morphological characterization of BAU Aam-6

Morphological characters of BAU Aam-7

Parameters	Units	Photographs
Age of plant	5 years	
Height	321.66 cm	
Canopy spreading (N-S)	272.33 cm	
Canopy spreading (E-W)	281.00 cm	
Base girth	40.53cm	
Leaf blade length	25.18 cm	
Leaf blade width	5.94 cm	
Petiole length	4.94 cm	
Leaf apex shape	Acute	
Leaf base shape	Acute	
Leaf margin	Wavy	
Colour of young leaf		
Colour of fully developed leaf	Green	
Regularity of flowering	Regular	
Inflorescence shape	Conical	
Inflorescence length	35.20 cm	
Inflorescence width	19.24 cm	
Fruit weight	407.66 g	
Fruit length	12.14 cm	
Fruit width	7.49 cm	
Fruit thickness	7.19 cm	
Volume of fruit	396.66 CC	
Fruit shape	Oblong	
Shape of fruit apex	Obtuse	
Skin colour of ripe fruit	Greenish yellow	
Depth of fruit stalk cavity	Absent	
Fruit neck prominence	Prominent	
Slope of fruit ventral shoulder	Slopping abruptly	
Fruit beak type	Pointed	
Fruit sinus type	Absent	
Fruit skin waxiness	Waxy	
Skin surface texture	Rough	
Weight of skin	54.00 g	
Skin thickness	0.14 cm	
Pulp colour	Orange	
Pulp texture	Intermediate	
Adherence of fruit skin to pulp	Intermediate	
Quantity of fiber in pulp	Medium	
Fiber length in the pulp	Medium	
Pulp content	314.00 g	
Stone length	10.09 cm	
Stone width	4.06 cm	
Stone thickness	1.94 cm	
Stone weight	39.66 g	
Quantity of fiber on stone	Medium	
Seed length	7.26 cm	

Fig. Morphological characterization of BAU Aam-7

Seed width	3.17 cm
Seed weight	22.33 g
Seed shape	Ellipsoid
Type of embryony	Poly embryony
TSS (%)	20.56
pH	4.67
Titratable acid (%)	0.230
Vit C content (mg/100g)	15.30
%RS	4.29
%NRS	8.72
%TS	13.01
β-Carotene (µg/100g)	40.70
% MC	76.44

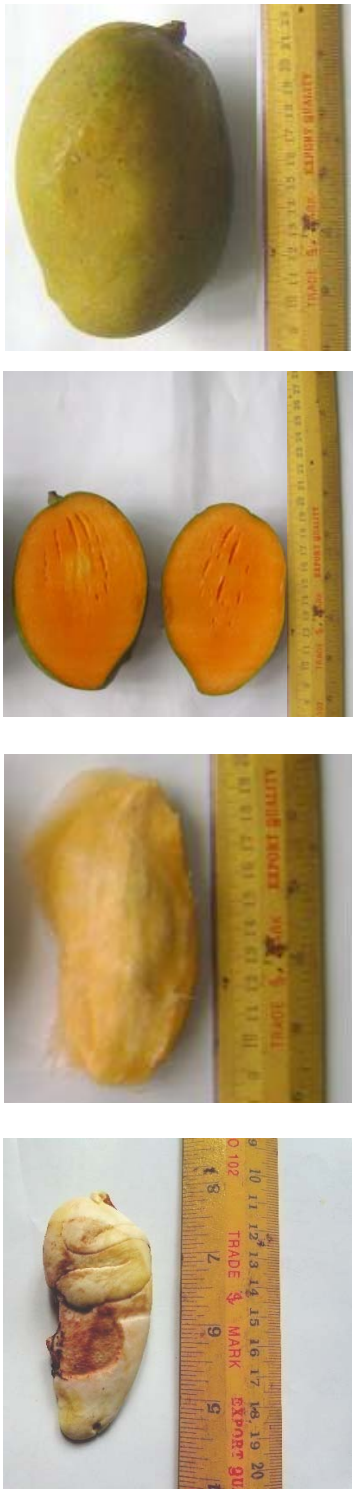


Fig. Morphological characterization of BAU Aam-7

Morphological characters of BAU Aam-8

Parameters	Units	Photographs
Age of plant	5 years	
Height	355.00 cm	
Canopy spreading (N-S)	346.66 cm	
Canopy spreading (E-W)	311.33 cm	
Base girth	41.76 cm	
Leaf blade shape	Lanceolate	
Leaf blade length	23.94 cm	
Leaf blade width	6.10 cm	
Petiole length	5.16 cm	
Leaf apex shape	Acute	
Leaf base shape	Acute	
Leaf margin	Wavy	
Colour of young leaf		
Colour of fully developed leaf	Green	
Regularity of flowering	Regular	
Inflorescence position		
Inflorescence shape	Conical	
Inflorescence length	38.14 cm	
Inflorescence width	19.86 cm	
Fruit weight	363.66 g	
Fruit length	11.52 cm	
Fruit width	7.44 cm	
Fruit thickness	7.02 cm	
Volume of fruit	353.66 ml	
Fruit shape	Oblong	
Shape of fruit apex	Obtuse	
Skin colour of ripe fruit	Greenish yellow	
Depth of fruit stalk cavity	Absent	
Fruit neck prominence	Prominent	
Slope of fruit ventral shoulder	Slopping abruptly	
Fruit beak type	Pointed	
Fruit sinus type	Absent	
Fruit skin waxiness	Waxy	
Skin surface texture	Rough	
Weight of skin	35.00 g	
Skin thickness	0.12 cm	
Pulp colour	Deep orange	
Pulp texture	Intermediate	
Adherence of fruit skin to pulp	Intermediate	
Quantity of fiber in pulp	Medium	
Fiber length in the pulp	Medium	
Pulp content	292.00 g	
Stone length	9.29 cm	
Stone width	4.02 cm	
Stone thickness	1.81 cm	
Stone weight	36.66 g	

Fig. Morphological characterization of BAU Aam-8

Parameters	Units	Photographs
Veins on stone	Long and prominent	
Quantity of fiber on stone	Long	
Seed length	6.23 cm	
Seed width	2.91 cm	
Seed weight	17.66 g	
Seed shape	Ellipsoid	
Type of embryony	Polyembryony	
TSS (%)	20.4	
pH	4.71	
Titratable acid (%)	0.084	
Vit C content (mg/100g)	13.80	
%RS	4.31	
%NRS	8.76	
%TS	13.07	
β-Carotene (µg/100g)	89.71	
% MC	80.92	

Fig. Morphological characterization of BAU Aam-8

Morphological characters of BAU Aam-9

Parameters	Units	Photographs
Age of plant	5 years	
Height	265.66	
Canopy spreading (N-S)	217.00 cm	
Canopy spreading (E-W)	221.33 cm	
Base girth	45.00 cm	
Leaf blade shape	Ovate	
Leaf blade length	14.52 cm	
Leaf blade width	5.08 cm	
Petiole length	2.82 cm	
Leaf apex shape	Acute	
Leaf base shape	Obtuse	
Leaf margin	Wavy	
Colour of young leaf		
Colour of fully developed leaf	Green	
Regularity of flowering	Regular	
Inflorescence position		
Inflorescence shape	Conical	
Inflorescence length	31.0 cm	
Inflorescence width	27.50 cm	
Fruit weight	170.33 g	
Fruit length	9.09 cm	
Fruit width	5.72 cm	
Fruit thickness	5.15 cm	
Volume of fruit	155.33 ml	
Fruit shape	Elliptic	
Shape of fruit apex	Obtuse	
Skin colour of ripe fruit	Yellowish with purple blotch	
Depth of fruit stalk cavity	Absent	
Fruit neck prominence	Slightly prominent	
Slope of fruit ventral shoulder	Slopping abruptly	
Fruit beak type	Perceptible	
Fruit sinus type	Absent	
Fruit skin waxiness	Waxy	
Skin surface texture	Rough	
Weight of skin	44.33 g	
Skin thickness	0.25	
Pulp colour	Orange	
Pulp texture	Intermediate	
Adherence of fruit skin to pulp	Intermediate	
Quantity of fiber in pulp	High	
Fiber length in the pulp	Long	
Pulp content	82.66 g	

Fig. Morphological characterization of BAU Aam-9

Parameters	Units	Photographs
Stone length	7.46 cm	  Fig. Morphological characterization of BAU Aam-9
Stone width	3.50 cm	
Stone thickness	2.19 cm	
Stone weight	43.33 g	
Veins on stone	Elevated	
Quantity of fiber on stone	High	
Seed length	6.19 cm	
Seed width	2.50 cm	
Seed weight	19.66 g	
Seed shape	Ellipsoid	
Type of embryony	Monoembryony	
TSS (%)	21.83	
pH	5.29	
Titratable acid (%)	0.384	
Vit-C content (mg/100g)	5.4	
%RS	3.90	
%NRS	7.25	
%TS	11.15	
β-Carotene (µg/100g)	55.64	
% MC	79.38	

Morphological characters of BAU Aam-10

Parameters	Units	Photographs
Age of plant	5 years	
Height	252.50 cm	
Canopy spreading (N-S)	216.00 cm	
Canopy spreading (E-W)	254.00 cm	
Base girth	34.20 cm	
Leaf blade shape	Lanceolate	
Leaf blade length	19.02 cm	
Leaf blade width	5.20 cm	
Petiole length	3.70 cm	
Leaf apex shape	Acute	
Leaf base shape	Acute	
Leaf margin	Wavy	
Colour of young leaf		
Colour of fully developed leaf	Green	
Regularity of flowering	Regular	
Inflorescence position		
Inflorescence shape	Conical	
Inflorescence length	32.6 cm	
Inflorescence width	15.6 cm	
Inflorescence colour	Yellowish green	
Fruit weight	360.66 g	
Fruit length	11.24 cm	
Fruit width	7.11 cm	
Fruit thickness	6.66 cm	
Volume of fruit	344.66 ml	
Fruit shape	Obovoid	
Shape of fruit apex	Apex	
Skin colour of ripe fruit	Greenish yellow	
Depth of fruit stalk cavity	Absent	
Fruit neck prominence	Absent	
Slope of fruit ventral shoulder	Slopping abruptly	
Fruit beak type	Perceptible	
Fruit sinus type	Shallow	
Fruit skin waxiness	Waxy	
Skin surface texture	Rough	
Weight of skin	57.33 g	
Skin thickness	0.18 cm	
Pulp texture	Rough	
Pulp content	261.33 g	
Stone length	9.42 cm	
Stone width	4.00 cm	
Stone thickness	2.08 cm	
Stone weight	42.00 g	
Seed length	5.80 cm	

Fig. Morphological characterization of BAU Aam-10

Parameters	Units	Photographs
Seed width	2.69 cm	
Seed weight	17.0 g	
Seed shape	Reniform	
Type of embryony	Monoembryony	
TSS (%)	18.13	
pH	4.36	
Titratable acid (%)	0.128	
Vit C content (mg/100g)	4.50	
%RS	2.64	
%NRS	6.80	
%TS	9.44	
β-Carotene (µg/100g)	86.39	
% MC	79.84	

Fig. Morphological characterization of BAU Aam-10

Morphological characters of BAU Aam-11

Parameters	Units	Photographs
Age of plant	5 years	
Height	210.66 cm	
Canopy spreading (N-S)	155.00 cm	
Canopy spreading (E-W)	166.00 cm	
Base girth	25.46 cm	
Leaf blade shape	Oblong	
Leaf blade length	24.24 cm	
Leaf blade width	5.84 cm	
Petiole length	4.04 cm	
Leaf apex shape	Acuminate	
Leaf base shape	Acute	
Leaf margin	Wavy	
Colour of fully developed leaf	Green	
Regularity of flowering	Regular	
Inflorescence position		
Inflorescence shape	Pyramidal	
Inflorescence length	36.90 cm	
Inflorescence width	23.78 cm	
Inflorescence colour	Greenish	
Fruit weight	257.00 g	
Fruit length	12.32 cm	
Fruit width	6.25 cm	
Fruit thickness	5.92 cm	
Volume of fruit	235.00 ml	
Fruit shape	Oblong	
Shape of fruit apex	Acute	
Skin colour of ripe fruit	Green	
Depth of fruit stalk cavity	Absent	
Fruit neck prominence	Absent	
Slope of fruit ventral shoulder	Slopping abruptly	
Fruit beak type	Pointed	
Fruit skin waxiness	Waxy	
Skin surface texture	Rough	
Weight of skin	34.66 g	
Skin thickness	0.17 cm	
Pulp colour	Yellow	
Pulp texture	Hard	
Adherence of fruit skin to pulp	Strong	
Quantity of fiber in pulp	Low	
Fiber length in the pulp	Short	
Pulp content	181.66 g	
Stone length	10.85 cm	
Stone width	3.38 cm	

Fig. Morphological characterization of BAU Aam-11

Parameters	Units	Photographs
Stone thickness	1.93 cm	
Stone weight	40.66 g	
Veins on stone	Prominent	
Quantity of fiber on stone	Low	
Seed length	6.36 cm	
Seed width	2.71 cm	
Seed weight	18 g	
Seed shape	Oblong	
Type of embryony	Monoembryony	
TSS (%)	24.0	
pH	4.50	
Titratable acid (%)	0.192	
Vit C content	4.50	
%RS	5.88	
%NRS	15.86	
%TS	21.74	
β-Carotene (µg/100g)	44.35	
% MC	78.37	

Fig. Morphological characterization of BAU Aam-11

Morphological characters of BAU Aam-12

Parameters	Units	Photographs
Age of plant	5 years	
Height	252.00 cm	
Canopy spreading (N-S)	165.00 cm	
Canopy spreading (E-W)	152.00 cm	
Base girth	32.00 cm	
Leaf blade shape	Oblong	
Leaf blade length	18.96 cm	
Leaf blade width	5.32 cm	
Petiole length	3.34 cm	
Leaf apex shape	Acute	
Leaf base shape	Acute	
Leaf margin	Entire	
Colour of young leaf		
Colour of fully developed leaf	Light green	
Regularity of flowering	Regular	
Inflorescence position		
Inflorescence shape	Pyramidal	
Inflorescence length	25.4 cm	
Inflorescence width	18.70 cm	
Inflorescence colour	Greenish yellow	
Fruit weight	323.66 g	
Fruit length	9.23 cm	
Fruit width	7.79 cm	
Fruit thickness	6.97 cm	
Volume of fruit	283.33	
Fruit shape	Obovoid	
Shape of fruit apex	Obtuse	
Skin colour of ripe fruit	Greenish yellow	
Depth of fruit stalk cavity	Absent	
Fruit neck prominence	Absent	
Slope of fruit ventral shoulder	Ending in a long curve	
Fruit beak type	Perceptible	
Fruit sinus type	Deep	
Fruit skin waxiness	Waxy	
Skin surface texture	Smooth	
Weight of skin	42.33 g	
Skin thickness	0.13 cm	
Pulp colour	Yellow	
Pulp texture	Intermediate	
Adherence of fruit skin to pulp	Strong	
Quantity of fiber in pulp	Low	
Fiber length in the pulp	Long	
Pulp content	229.33 g	
Stone length	7.56 cm	
Stone width	4.51 cm	
Stone thickness	2.37 cm	

Fig. Morphological characterization of BAU Aam-12

Parameters	Units	Photographs
Stone weight	52.00 g	
Veins on stone	Elevated	
Quantity of fibre on stone	Low	
Seed length	6.46 cm	
Seed width	3.12 cm	
Seed weight	32.33 g	
Seed shape	Reniform	
Type of embryony	Monoembryony	
TSS (%)	22.53%	
pH	5.21	
Titratable acid (%)	0.224	
Vit C content	6.00	
%RS	7.24	
%NRS	4.6	
%TS	11.84	
β-Carotene (µg/100g)	54.85	
% MC	77.04	

Fig. Morphological characterization of BAU Aam-12

Morphological characters of BAU Aam-13

Parameters	Units	Photographs
Age of plant	5 years	
Height	225.66 cm	
Canopy spreading (N-S)	165.00 cm	
Canopy spreading (E-W)	160.00 cm	
Base girth	26.50 cm	
Leaf blade shape	Lanceolate	
Leaf blade length	24.36 cm	
Leaf blade width	5.62 cm	
Petiole length	4.42 cm	
Leaf apex shape	Acuminate	
Leaf base shape	Acute	
Leaf margin	Entire	
Colour of young leaf		
Colour of fully developed leaf	Green	
Regularity of flowering	Regular	
Inflorescence position		
Inflorescence shape	Pyramidal	
Inflorescence length	28.15 cm	
Inflorescence width	20.72 cm	
Inflorescence colour	Greenish red	
Fruit weight	245.33 g	
Fruit length	11.88 cm	
Fruit width	5.96 cm	
Fruit thickness	5.75 cm	
Volume of fruit	224.00 ml	
Fruit shape	Oblong	
Shape of fruit apex	Acute	
Skin colour of ripe fruit	Light green	
Depth of fruit stalk cavity	Absent	
Fruit neck prominence	Absent	
Slope of fruit ventral shoulder	Slopping abruptly	
Fruit beak type	Pointed	
Fruit sinus type	Absent	
Fruit skin waxiness	Waxy	
Skin surface texture	Rough	
Weight of skin	30.00	
Skin thickness	0.13 cm	
Pulp colour	Yellow	
Pulp texture	Intermediate	
Adherence of fruit skin to pulp	Strong	
Quantity of fiber in pulp	Low	
Fiber length in the pulp	Long	

Fig. Morphological characterization of BAU Aam-13

Parameters	Units	Photographs
Pulp content	161.00 g	
Stone length	10.81 cm	
Stone width	3.46 cm	
Stone thickness	1.95 cm	
Stone weight	54.33 g	
Veins on stone	Prominent	
Quantity of fiber on stone	Medium	
Seed length	6.85 cm	
Seed width	2.80 cm	
Seed weight	28 g	
Seed shape	Oblong	
Type of embryony	Monoembryony	
TSS (%)	21.73	
pH	5.21	
Titratable acid (%)	0.16	
Vit C content (mg/100g)	4.50	
%RS	7.04	
%NRS	4.17	
%TS	11.21	
β-Carotene (µg/100g)	38.56	
% MC	80.96	

Fig. Morphological characterization of BAU Aam-13

Morphological characters of BAU Aam-14

Parameters	Units	Photographs
Age of plant	5 years	
Height	225.00 cm	
Canopy spreading (N-S)	207.33 cm	
Canopy spreading (E-W)	230.00 cm	
Base girth	32.76 cm	
Leaf blade shape	Eliptic	
Leaf blade length	22.02 cm	
Leaf blade width	4.84 cm	
Petiole length	2.72 cm	
Leaf apex shape	Acute	
Leaf base shape	Obtuse	
Leaf margin	Entire	
Colour of young leaf		
Colour of fully developed leaf	Light green	
Regularity of flowering	Regular	
Inflorescence shape	Conical	
Inflorescence length	43.18 cm	
Inflorescence width	24.58 cm	
Inflorescence colour	Reddish	
Fruit weight	306.33 g	
Fruit length	14.46 cm	
Fruit width	6.18 cm	
Fruit thickness	5.43 cm	
Volume of fruit	280.00 ml	
Fruit shape	Oblong	
Shape of fruit apex	Acute	
Skin colour of ripe fruit	Yellow	
Depth of fruit stalk cavity	Absent	
Fruit neck prominence	Absent	
Slope of fruit ventral shoulder	Ending in a long curve	
Fruit beak type	Shallow	
Fruit sinus type	Absent	
Fruit skin waxiness	Waxy	
Skin surface texture	Rough	
Weight of skin	46.33 g	
Skin thickness	0.14 cm	
Pulp colour	Yellow orange	
Pulp texture	Medium soft	
Adherence of fruit skin to pulp	Medium	
Quantity of fiber in pulp	Medium	
Fiber length in the pulp	Long	
Pulp content	238.66 g	
Stone length	12.37 cm	
Stone width	3.22 cm	
Stone thickness	1.36 cm	
Stone weight	21.66 g	

Fig. Morphological characterization of BAU Aam-14

Parameters	Units	Photographs
Veins on stone	Long and prominent	
Quantity of fibre on stone	Low	
Seed length	4.93 cm	
Seed width	2.43 cm	
Seed weight	9.0 g	
Seed shape	Ellipsoid	
Type of embryony	Monoembryony	
TSS (%)	23.83	
pH	5.46	
Titratable acid (%)	0.128	
Vit C content (mg/100g)	4.50	
%RS	5.41	
%NRS	8.47	
%TS	13.88	
β-Carotene (µg/100g)	31.27	
% MC	73.11	

Fig. Morphological characterization of BAU Aam-14

Morphological characters of BAU Aam-15

Parameters	Units	Photographs
Age of plant	5 years	
Height	260.00 cm	
Canopy spreading (N-S)	162.00 cm	
Canopy spreading (E-W)	220.00 cm	
Base girth	38.20 cm	
Leaf blade shape	Ovobate	
Leaf blade length	21.16 cm	
Leaf blade width	6.36 cm	
Petiole length	4.14 cm	
Leaf apex shape	Acute	
Leaf base shape	Obtuse	
Leaf margin	Wavy	
Colour of young leaf	Pinkish	
Colour of fully developed leaf	Green	
Regularity of flowering	Regular	
Inflorescence shape	Broadly pyramidal	
Inflorescence length	35.58 cm	
Inflorescence width	18.56 cm	
Inflorescence colour	Light raddish	
Type of flower		
Fruit weight	212.66 g	
Fruit length	8.19 cm	
Fruit width	6.79 cm	
Fruit thickness	6.75 cm	
Volume of fruit	202.66 ml	
Fruit shape	Roundish	
Shape of fruit apex	Obtuse	
Skin colour of ripe fruit	Greenish yellow	
Depth of fruit stalk cavity	Shallow	
Fruit neck prominence	Absent	
Slope of fruit ventral shoulder	Ending in a long curve	
Fruit beak type	Perceptible	
Fruit sinus type	Shallow	
Fruit skin waxiness	Waxy	
Skin surface texture	Rough	
Weight of skin	34.66 g	
Skin thickness	0.18 cm	
Pulp colour	Yellow orange	
Pulp texture	Intermediate	
Adherence of fruit skin to pulp	Intermediate	
Quantity of fiber in pulp	Medium	
Fiber length in the pulp	Long	
Pulp content	142.00 g	
Stone length	6.19 cm	
Stone width	3.69 cm	
Stone thickness	2.19 cm	

Fig. Morphological characterization of BAU Aam-15

Parameters	Units	Photographs
Stone weight	36.00 g	
Veins on stone	Prominent	
Quantity of fiber on stone	High	
Seed length	5.20 cm	
Seed width	2.59 cm	
Seed weight	20.5 g	
Seed shape	Reniform	
Type of embryony	Monoembryony	
TSS (%)	22.66	
pH	4.61	
Titratble acid	0.16	
Vit C content (mg/100g)	17.50	
%RS	7.69	
%NRS	5.39	
%TS	13.08	
β-Carotene (µg/100g)	37.62	
% MC	72.64	

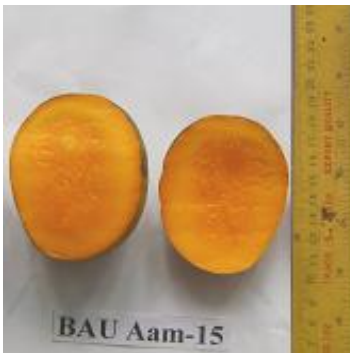


Fig. Morphological characterization of BAU Aam-15

Morphological characters of BAU Aam-16

Parameters	Units	Photographs
Age of plant	5 years	
Height	280.00 cm	
Canopy spreading (N-S)	170.00 cm	
Canopy spreading (E-W)	200.00 cm	
Base girth	40.60 cm	
Leaf blade shape	Oblong	
Leaf blade length	24.40 cm	
Leaf blade width	6.46 cm	
Petiole length	4.02 cm	
Leaf apex shape	Acute	
Leaf base shape	Acute	
Leaf margin	Wavy	
Colour of young leaf		
Colour of fully developed leaf	Light green	
Regularity of flowering	Regular	
Inflorescence position		
Inflorescence shape	Pyramidal	
Inflorescence length	31.10 cm	
Inflorescence width	24.74 cm	
Inflorescence colour	Raddish	
Fruit weight	279.00 g	
Fruit length	9.04 cm	
Fruit width	7.14 cm	
Fruit thickness	7.00 cm	
Volume of fruit	266.00 ml	
Fruit shape	Obovoid	
Shape of fruit apex	Obtuse	
Skin colour of ripe fruit	Yellow	
Depth of fruit stalk cavity	Medium	
Fruit neck prominence	Absent	
Slope of fruit ventral shoulder	Ending in a long curve	
Fruit beak type	Perceptible	
Fruit sinus type	Shallow	
Fruit skin waxiness	Non waxy	
Skin surface texture	Rough	
Weight of skin	38.66 g	
Skin thickness	0.11 cm	
Pulp colour	Deep orange	
Pulp texture	Soft	
Adherence of fruit skin to pulp	Soft	
Quantity of fiber in pulp	Absent	
Pulp content	201.00 g	
Stone length	6.77 cm	

Fig. Morphological characterization of BAU Aam-16

Parameters	Units	Photographs
Stone width	3.85 cm	
Stone thickness	2.10 cm	
Stone weight	39.33 g	
Veins on stone	Level with surface	
Quantity of fiber on stone	Low	
Seed length	5.96 cm	
Seed width	2.76 cm	
Seed weight	24.5 g	
Seed shape	Reniform	
Type of embryony	Monoembryony	
TSS(%)	23.56	
pH	5.27	
Titratable acid (%)	0.192	
Vit C content (mg/100g)	4.05	
%RS	6.02	
%NRS	9.81	
%TS	15.83	
β-Carotene (µg/100g)	53.65	
% MC	81.87	
		Fig. Morphological characterization of BAU Aam-16

Morphological characters of BAU Aam-17

Parameters	Units	Photographs
Age of plant	5 years	
Height	190.00 cm	
Canopy spreading (N-S)	130.00 cm	
Canopy spreading (E-W)	175.00 cm	
Base girth	31.50 cm	
Leaf blade shape	Lanceolate	
Leaf blade length	26.10 cm	
Leaf blade width	5.76 cm	
Petiole length	4.82 cm	
Leaf apex shape	Acuminate	
Leaf base shape	Acute	
Leaf margin	Wavy	
Colour of young leaf		
Colour of fully developed leaf	Light green	
Regularity of flowering	Regular	
Inflorescence position		
Inflorescence shape	Conical	
Inflorescence length	33.4 cm	
Inflorescence width	13.1 cm	
Inflorescence colour	Yellow	
Fruit weight	249.33 g	
Fruit length	10.38 cm	
Fruit width	6.92 cm	
Fruit thickness	6.17 cm	
Volume of fruit	222.33 ml	
Fruit shape	Obovoid	
Shape of fruit apex	Acute	
Skin colour of ripe fruit	Yellowish green	
Depth of fruit stalk cavity	Absent	
Fruit neck prominence	Slightly	
Slope of fruit ventral shoulder	Slopping abruptly	
Fruit beak type	Perceptible	
Fruit sinus type	Shallow	
Fruit skin waxiness	Waxy	
Skin surface texture	Smooth	
Weight of skin	38.66 g	
Skin thickness	0.13 cm	
Pulp colour	Orange	
Pulp texture	Firm	
Adherence of fruit skin to pulp	Strong	
Quantity of fiber in pulp	High	
Fiber length in the pulp	Long	
Pulp content	172.00g	
Stone length	8.77 cm	
Stone width	4.03 cm	
Stone thickness	1.84 cm	

Fig. Morphological characterization of BAU Aam-17

Parameters	Units	Photographs
Stone weight	35.33 g	
Veins on stone	Elevated	
Quantity of fiber on stone	High	
Seed length	5.25 cm	
Seed width	2.65 cm	
Seed weight	10.47 g	
Seed shape	Ellipsoid	
Type of embryony	Monoembryony	
TSS (%)	19.76	
pH	5.28	
Titratable acid (%)	0.256	
Vit C content (mg/100g)	2.25	
%RS	2.73	
%NRS	7.38	
%TS	10.11	
β-Carotene (µg/100g)	55.38	
% MC	79.01	

Fig. Morphological characterization of BAU Aam-17

C) Morphological characterization of GI aroids

Aroids are a nutritionally rich and well adapted crops in our country. It is also played a great role of vegetable supply in the lean period when other vegetables are almost absent in the market. Numerous GI aroids are grown in many areas of Bangladesh. It is necessary to characterize them to protect piracy. Although aroids was not assigned crop in our part. Later on it was included in BAU-part. Therefore, we have done some preliminary works on aroids, as a result we could not provide details findings on aroids. Therefore, further details study on morphological and molecular characterization of aroids are very much needed in future. However, morphological characterization of some GI aroids are given below:

1) Giant taro (Man Kachu)

Collected from: Khulna, Ishurdi, Jessore, Patuakhali, Trishal, Gazipur, Bhola, Chittagong

Giant taro locally known as *Maan kachu* or *Fan kachu* (Bangladesh) is under the genus *Alocasia* of the family Araceae. It is a genus of broad-leaved rhizomatous or tuberous perennials.Grand rhizomes weight varies from 10 kg to several kg and male sterile; Giant Maan kachu is widely grown in the homestead of southern and northern parts of Bangladesh.

Items	Morphological characters	Photographs
Plant habit	The whole plant (Fig. 1) can stand 3-5 m tall and spread 1.5-3.5 m across	 Fig. 1. The whole plant of giant taro
Leaf	Giant taro is a massive perennial with huge elephant ear leaves (Fig. 2) 1-2 m in length and 60-130 cm wide borne on leaf stalks 50-100 cm long. The leaves are borne on long petioles which arise from the stem and are sheathing on the lower half, but the blades are more or less heart-shaped with rather rounded basal lobes: the blades point upwards forming a straight line with the petiole. They are usually green, but there are variegated forms which are blotched or mottled with white.	  Fig. 2. Leaves of giant taro

Stem	The stem is edible, but contains raphid or raphide crystals of oxalic acid that can mumb and swell the tongue and pharynx resulting in difficult breathing, and sharp throat pain (Fig. 3).	 Fig. 3. Rhizome and edible parts
Inflorescence	Beautiful araceous flowers grow at the end of a short stalk. The lower parts contain more of the poison. The greenish spathe and spadix (Fig. 4a-b) stands 20.3-25.4 cm tall and is not particularly showy. Inflorescences 2 or more in each axil with boat-shaped spathe. Peduncles usually shorter than the petioles.	 Fig. 4. (a) Petioles and (b) spadix of giant taro
Sucker	5 to 6 or many. Small leaf and pale green in colour (Fig.5).	 Fig. 5. Suckers of giant taro
Cormel	A large woody tuber. Weight up to 8 to 10 kg after for 3-4 years (Fig. 6).	 Fig. 6. Cormel of giant taro
Root	Tiny white partial roots are observed. (Fig. 7).	 Fig. 7. Partial roots of giant taro
Speciality	The woody tubers can be stored for a long period. The corms and leaf juices are reported to be used for medicinal purposes in Bangladesh.	

2) Elephant foot yam (Ol Kachu)
Collected from: Ishurdi, Jessore, Khulna

Elephant foot yam, locally known as olkachu in Bangladesh is under the genus *Amorphophallus* of the family Araceae. It is one of the most nutritious tuberous vegetable crops. It is a potential vegetable for lean period in Bangladesh (August to November). It is mainly grown in northern and southern region of Bangladesh.

Items	Morphological characters	Photographs
Plant habit	Elephant foot yam is a perennial, apparently stem less herb (Fig. 1). The 'stem' like structure (Fig. 2), which bears the lamina, is merely the petiole (1m or more high), radically developed from the corm.	 Fig. 1. Elephant foot yam standing plant uprooted plant  Fig. 2. Stem like but petiole structure of elephant foot yam
Leaf	The leaves (Fig. 3a-b) are usually solitary, with the blades up to 1 m in diameter, foetid when in flower.	 Fig. 3a-b. Leaves of elephant foot yam (a) young leaves
Flower	A single inflorescence which consisting of an elongate or ovatespathe usually envelops the spadix (Fig.4). The spathe can have different colors, but mostly brownish-purple or whitish-green. The spadix has tiny flowers, female flowers, like as a pistil, at the bottom, the male flowers are sterile, actually a group of stamens, and then a blank sterile area. The appendix, consists of sterile flowers.	 Fig. 4. Flowers of elephant foot yam

Items	Morphological characters	Photographs
Sucker	The plants have 2-3 sucker developed from the roots (Fig. 5).	 Fig. 5. Sucker of elephant foot yam
Corm	The corm (Fig. 6) is depressed-globose, up to 30 cm in diameter, flowering before leafing every year from the previous year's corm. The plants have fibrous root system	  Fig. 6. Depressed-globose corm of elephant foot yam
Root	The plants have fibrous root system (Fig. 7).	 Fig. 7. Fibrous root of elephant foot yam with sucker
Speciality	It can be stored as food for the future, can be useful for diabetes and ulcer patient. This vegetable has potential to improve nutrition, boost up food security, faster rural development.	

3) Panchamukhi Kachu

Collected from: Muktagacha and Fulbaria (Mymensingh) Modhupur and Chittagong Hill Tracts

The plant is of a short structure, around 26.035cm in height. Its foliage is almost indistinguishable from that of mukhi kachu. As it grows, its growing point is divided into branches, typically 5, each of which may give rise to a shoot.

Taro, locally known as Panchamukhi kachu in Bangladesh is under the genus *Colocasia* of the family Araceae. In Bangladesh it is cultivated as food crop.

Items	Morphological characters	Photographs
Plant	Taro plant (Fig. 1) produces heart shaped peltate leaves (Fig. 2) 60-90 cm long and 60-90 cm across on 90 cm long petioles that all originate from an upright corm. The petioles are thick and succulent. The corm (Fig. 4) is conical shaped like a top with rough ridges, lumps and spindly roots, and usually weighs around 0.5-0.9 kg, but occasionally as much as 3.6 kg. The skin is brown and the flesh is white or pink. Sometimes one or two cormels are found to develop from the lower portion of the corm. In most cases the upper portion of the corm is divided into five or more parts and each part develops shoot (Fig. 3).	 Fig. 1. Taro (Panchamukhi kachu) plant
Leaf	Leaves peltate, 35.56cm long, 25.4 cm broad, more roundish than other mukhi kachu. Lamina thick, bright green, veins light green, petiole 27.94cm, Average no of leaves 10 to12 (Fig. 2).	 Fig. 2. Leaves of Taro
Flower	No inflorescence.	
Sucker	No. of suckers 4 to 8. Stolon absent (Fig. 3).	 Fig. 3. Suckers or Propagating unit of Taro

Items	Morphological characters	Photographs
Corm	Corm irregularly shaped with upperside flatter and tapering towards the base, weight ranges 170.1to 283.05 g (Fig. 4).	 Fig. 4. Corms of Taro
Root	Fibrous root system (Fig. 5).	 Fig. 5. Roots of Taro
Speciality	Panchamukhi kachu particularly popular in Garo Hilly areas of Mymensingh and Tangail, also extensively grows in Chittagong Hill Tracts.	

4) Eddoe (Poidnal Kachu)

Collected from Modhupur, Muktagacha and Fulbaria upazilla of Tangail & Mymensingh distrct

Eddoe locally known as Poidnal / Bash kachu is under the genus *Colocasia* of the family Araceae. Its cultivation is concentrated in the regions of 'Modhupur' of 'Tangail', 'Fulbaria' and Muktagasa of 'Mymensingh' and 'Vawal' of 'Gazipur' districts in Bangladesh. Eddoe is herbaceous perennial plant (Fig. 1) with a large elongated rhizome on or just below the ground surface.

Items	Morphological characters	Photographs
Plant habit	The plant consists of a cylindrical corm, depending upon the age of plant, have deep violet foliage. An average height of plant 73.66cm (Fig. 1).	 Fig. 1. Eddoe plants showing leaves and petioles in field
Leaf	Leaves peltate, deep green with a violet tinge; lamina elliptical in outline, 27.94x20.32cm,veins lighter coloured than the leaves; Petiole purple, 50.08cm long, no. of leaves produced during the growing season was 13 to 14 on average. The leaves are large to very large, size may be 40.0cm × 24.8cm with a peltate shape. Petiole is 0.8 -1.2m in length, colour of leaf blade and petiole is violet. (Fig. 2).	 Fig. 2. Leaf and petioles of Eddoe plant
Sucker	No. of sucker varied from 7-12.	
Corm and Cormel	Cormel basically cylindrical but tapering towards the apex, individual corm up to 396.09 to 680.04g in weighing, 8cm in diameter with small side elongated cormel 113.4 to 226.08 g in weight, flesh white, no. of cormels up to 1-4 per hill. The corm and cormel are the edible part of the plant (Fig. 3).	 Fig. 3. Cormel of Eddoe plant

Items	Morphological characters	Photographs
Root	Tiny side fibrous root system (Fig. 4).	 Fig. 4. Fibrous root
Speciality	Poidnal kachu is a root vegetable which plays an important role as summer vegetable when other vegetables are scarce in the market. The starchy edible corm is used in curry, fried and used as side dish with rice, chapattiy. Village people also prepared curry with small fishes.	

5) Salad Kachu (*Colocasia gigantea*)

Salad kachu or *Colocasia gigantea* is a perennial evergreen herb under the genus *Colocasia.* It has been found the Southeren China and Indo-Chaina to the Malay Peninsula and Sumatra and Java of Indoneshia. In Bangladesh, it is found in Bandarban, Khagrachari and Rangamati districts.

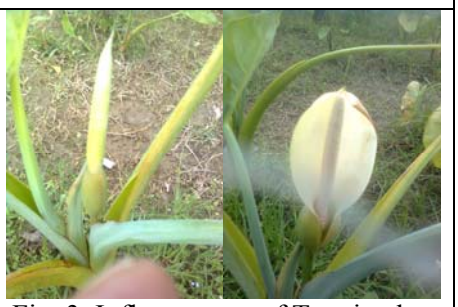
Collected from: Dewan gange, Bandarban

Items	Morphological characters	Photographs
Plant	Perennial ever green herb with a stout short above-ground stem up to 20-52cm long and 3.5-5.5cm in diameter (Fig. 1).	 Fig. 1. Whole plant of Salad Kachu
Leaf	Leaves several together, petiole light green, pruinose 80 to 100cm long, leaf blade ovate-cordate; Leaf peltate, green or pale green above, glaucous below, primary lateral veins 6 to 7 pairs (Fig. 2).	 Fig. 2. Leaves of Salad Kachu
Flower	Flowering of the plant is not an annual phenomenon but occurs at intervals of 6 to 7 years. So not yet observed.	
Sucker	3 to 4, trailing horizontally, branching, thin, pale green, 30 to 40cm long, 0.4 to 0.5cm in diameter (Fig. 3).	 Fig. 3. Sucker of Salad Kachu
Corm	One main large tubers or corm observed (Fig. 4).	 Fig. 4. Cormel of Salad Kachu
Root	Fibrous Root system (Fig. 5).	 Fig. 5. Roots of Salad Kachu
Speciality	In Bangladesh children and women are generally suffer from a deficiency of iron, calcium and Vit. C, so this plant may be consumed as a supplementary diet. The plant can be cultivated in the kitchen gardens for ready availability.	

6) Tannia, Yautia/ Dud Kachu

Collected from Dhaka, Gazipur, Khulna, Chittagong, Mymensingh and Bhola

Tannia, locally known as Moulovi kachu in Bangladesh is under the genus *Xanthosoma* of the family Araceae. It is a underutilized plant species mainly grows in shady areas of homestead. Tannia plant (Fig. 1) can reach a height of about 2 m and have a short erect stem and large, long-stalked sagittate or hastate leaves with various colours (Fig. 2). The inflorescence is borne below the leaves, with a pale green spathe. A corm is produced at the base of the plant and this bears several lateral corms (cormels), each 10-25 cm long.

Items	Morphological characters	Photographs
Plant habit	Perennial herb with tuberous stem which bears up to 10 or more lateral corms and cormels. Has thick erect stem (Fig. 1).	 Fig. 1. Tannia plant
Leaf	leaves petiolate, green and oval sagittate in outline, lobes sharp pointed; leaf blade simple hastate or compound up to 90.05cm, milky latex present in the tissue, dull dark green above, below glaucous. Petiole 1 m or more long with triangular basal lobes. The bottom veins almost marginal near the attachment of the petiole (Fig. 2).	 Fig. 2. Leaf of Tannia plant
Flower	Inflorescence in clusters, peduncled. spathe with a constriction between a basal convolute, green, 8 cm long persisten tube and an upper, deciduous, cream in colour, 13 cm long cymbiform limb. Spadix sessile, equal to or shorter than the spathe, female at the base, male at the top, 11 cm long and no terminal sterile appendage (Fig. 3).	 Fig. 3. Inflorescence of Tannia plant
Sucker	A few side sucker observed (Fig. 4).	 Fig. 4. Sucker of Tannia plant

Items	Morphological characters	Photographs
Corm	A few corm produced.	
Cormel	A number of irregular shaped cormel developed. Some of the cormels specially the thinner ones come out of the soil and develop into suckers (Fig. 5).	 Fig. 5. Cormel of Tannia plant
Root	Hairy fibrous root system (Fig. 6).	 Fig. 6. Roots of Tannia plant
Speciality	This plant is under cultivation as it produced starchy corms and used as foodstuff.	

7) Blue taro/Purple stem taro (Surma kachu)

Collected from Mymensingh, Pabna, Khulna.

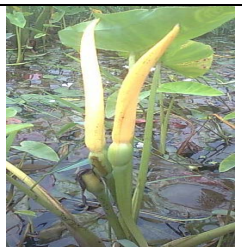
Blue Taro, locally known as 'Surma kachu' in Bangladesh is under the genus *Xanthosoma* of the family Araceae. In Bangladesh, it is grown in homestead area almost all over the country. Dudh kachu is a genus of about 50 species of tropical and sub-tropical arums in the flowering plant. The height of blue taro plant (Fig. 1) is about 1.2-1.8m. They are often grown for their edible leaves (Fig. 2) secreting with latex and the petioles which are purplish to violet in colour. The leaves may be arrow to lanceolate in shape. Flowers are looking very attractive in blooming stage. Backyard, kitchen garden under shade as perennial crops. In northern part of Bangladesh, it is also used as famine food. Sometimes *Phytophthora* rot may damage the crops. Mites also rolled up the leaves and hamper production.

Items	Morphological characters	Photographs
Plant habit	Terrestrial perennial herb, rhizome large (Fig. 1).	 Fig. 1. Blue taro Plant
Leaf	Leaves petiolated, petioles 30-70cm long, 1-4cm broad at the base, long-vaginate, brownish-violaceous, leaf blades at first somewhat pruinose, becoming green paler beneath, sagittate-ovate, 20-50cm long and 15-45cm wide or larger, acuminate – apiculate, glabrous, the basal lobes somewhat triangular, separated by an open. Produced 12-14 leaves during the growing season. The nerves and costa violaceous (Fig. 2 & Fig. 3).	 Fig. 2. Harvested semi tender leaves of blue taro  Fig. 3. Leaf of blue taro showing latex
Flower	No inflorescence.	
Sucker	Number of suckers varied from 2-6.	
Corm and Cormel	Corm elliptical with tapering apex. The skin of both corm and cormel purplish, flesh white but with a purplish tinge (Fig. 4).	 Fig. 4. Harvested corm and cormel of blue taro
Root	Hairy fibrous root system (Fig. 5).	 Fig. 5. Roots of blue taro

Items	Morphological characters	Photographs
Speciality	The leaves, petioles, leaf blades are used as vegetables. Tribal people of peru use the leaves as a pains reliever, to treat rheumatic pain in the legs. The milky juice from the peduncle of the plants is used to cure itchy skin and juice from the fruits is used to remove tape worms from the skin of dogs.	

8) Pani kachu/Shola kachu
Collected from: Trishal, Rangpur

Pani kachu is under the genus *Colocasia* of the family Araceae. The word pani kachu stande for a group of aroid varieties which are closely similar in structure and cultural method. Other names of the group include Shola Kachu, Mura Kachu and Bashpul kachu depending upon locality. Pani kachu is possibly the most important cultivated aroid of Bangladesh, most important in Sylhet, Mymensingh and Chittagong. It is the only aroid which can be grown under aquatic condition.

Items	Morphological characters	Photographs
Plant	The plant consist of a more or less erect cylindrical stem or rhizome, 91.44cm or more, the diameter of the mature stem varied from 7.62 to 12.7cm. The plant height around 92.83cm on the average (Fig. 1).	 Fig. 1. Plant of Pani kachu
Leaf	Leaves peltate, various shapes and sizes depending on the variety. Most of the varieties have purple striping on the petiole and a purplish shade in green leaf blade. Petioles almost vertically upright, no. of leaves varies up to 21-31 during growing period (Fig. 1 & 2).	 Fig. 2. Petiole of Pani kachu
Flower	Flowering profuse, up to 8 inflorescences per plant. Some varieties have smaller inflorescences (Fig. 3).	 Fig. 3. Flower of Pani kachu
Sucker/ Stolon	A common characteristic of the Pani kachu varieties is the formation of stolons. Size and thickness of stolons are like a pencil and are covered with scale leaves. After running on the ground for some distance the apex of the stolon thickness and form a sucker or off-shoot. No. of suckers varied 8 to17 per plant (Fig. 4).	 Fig. 4. Stolon of Pani kachu
Corm and cormel	No corm and cormel are present. Some of the buds or eyes of the rhizome may also develop directly into sucker.	

Items	Morphological characters	Photographs
Root	Hairy root system (Fig. 5).	 Fig. 5. Root of Pani kachu
Speciality	Only Pani kachu can be grown under aquatic condition; So in low lying areas, it can be easily grown rather than other vegetables.	

9) Shahebi kachu/Babu kachu (*Xanthosoma violaceum*)
Collected From: Bhola, Sylhet
Shahebi kachu, Babu kachu, Tel kachu and possibly many other names in different parts of the country. It is not grown commercially anywhere. Farmers usually maintain a few plants around the dwelling houses.

Items	Morphological characters	Photographs
Plant	Shahebi kachu has much in common with Dud kachu. The foliage of the plant is bright green in colour. An average height up to 48.26cm (Fig. 1).	 Fig. 1. Plant of Shahebi kachu
Leaf	Leaves arrow shaped with a somewhat acute sinus, lamina pruinose, bright green on the upper surface and whitish green underside. Veins prominent, lighter colour. No. of leaves 10-13per plant during growing season (Fig. 2).	 Fig. 2. Leaf of Shahebi kachu
Flower	No inflorescence observed.	
Sucker	Produced 1 to 3 suckers.	
Corms and Cormel	Corm round to irregularly shaped, up to 7-8 per plant, flesh white. Cormel somewhat elongated, branched and some of them develop into suckers (Fig. 3).	 Fig. 3. Corm of Shahebi kachu
Root	Fibrous root system (Fig. 4).	 Fig. 4. Roots of Shahebi kachu
Speciality	Shahebi kachu is not grown commercially but now a days in Bhola and some areas of Sylhet, it is very much popular for its foliage and corms. The leaves and corms are said to be free from acridity. The plant may be cultivated for corms alone.	

10) Mukhi Kachu (*Colocasia esculenta var. antiquarum*)

Collected from: Bogra, Potia

Mukhi kachu is under the genus *Colocasia* of the family Araceae. Mukhi kachu is also known as Chhora Kachu in some localities in our country. In English it is called Taro, dasheen. It has been an important foodstuff in tropical and subtropical regions for more than two thousand years. In Bangladesh, it is commercially cultivated all other the country. Almost the entire plant including the leaves, petioles, corms and stoloniferous runners are consumed as vegetables.

Items	Morphological characters	Photographs
Plant	Perennial herb with underground cormel and side corms. The plant is light green in colour, 39-46 cm long (Fig. 1).	 Fig. 1. Plant of Mukhi kachu
Leaf	Leaves petiolated, oblong-ovate, glaucous, petiole 25-75cm long, leaf blade peltate, 14-45x11-35cm, dark green above and light green beneath. Petiole stout and 1m or more in length. No. of leaf around 14to17 (Fig. 2).	  Fig. 2. Leaves and petioles of Mukhi kachu
Flower	No inflorescence.	
Sucker	Around 2-3 sucker developed on average.	
Corm and Cormel	A large number of cormels formed clustering round the small main central corm, corm flat round. Cormels 4 to 8 per hill, globular, flesh white (Fig. 3).	 Fig. 3. Corms of Mukhi kachu
Root	Fibrous root system (Fig. 4).	 Fig. 4. Roots of Mukhi kachu
Speciality	Mukhi kachu plays an important role as vegetables during lean period when other vegetables are scarce in the market. Taro is alkaline in reaction, so that Ulcer patient may be benefited if they have it.	

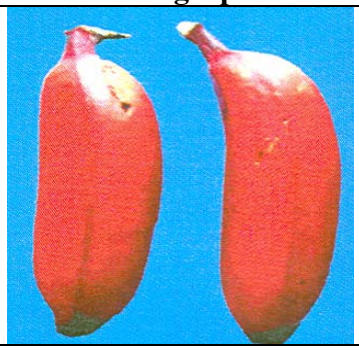
D) Morphological characterization of indigenous banana

Banana is a nutritionally rich and commercially cultivated crop in Bangladesh. Plenty of indigenous bananas are grown in around country. It is necessary to characterize them to protect piracy. Although indigenous banana was not assigned for this project, but it was included in BAU-part after consultation with PIU, BARC. As a result, we have done some preliminary works on it. Therefore, further study on morphological and molecular characterization of indigenous banana is required. However, morphological characterization of some indigenous banana is given below:

1) Local name: Agnissar Kala (*Musa sepientum*):

Collected from: Khagrachhari and one from Lama, Bandarban (eastern part of Bangladesh)

Items	Morphological characters	Photographs
Plant	The variety is cultivated only in very limited areas. A sample was collected from Khagrachhari and Lama, Bandarban (eastern part of Bangladesh).	 
Pseudostem	It grows up to 2.4-3m in height, but the stem is weak, dark pinkish in colour and shiny not waxy. So it cannot stand against strong wind or storm. Suckers are close to parent.	 
Leaf	Intermediate leaf habit, oval shape, petiole, petiole margins, midrib and leaf blade margins are also pinkish in colour. Leaves are wide, midrib is prominent and erect, veins are clear.	 

Items	Morphological characters	Photographs
Fruit	Fruit are also pinkish in colour. Fruit are seedless, but not that attractive in taste or flavour. Overall it has an ornamental value.	

2) **Local name: Aitta Kala (Densely seeded)**

Collected from: Lakhanpur – Gafargaon (Mymensingh) and BAU campus

Items	Morphological characters	Photographs
Plant	The variety can be found all over the country. The name bears the characteristics that the fruit is very densely seeded. Most variety of Aitta kala taste good. It is not grown commercially, but in rural areas it is widely used in preparing local cakes. Less care need to produce this variety in homestead area	 
Pseudostem	Pseudostem is quite long and strong, so medium size storm can not damage the plant. It can also with stand stagnant water, greenish in colour and waxy. Suckers are close to parent. Blotches are present at the petiole base, sparse blotching, black in colour.	 
Leaf	Drooping leaf habit, petiole, petiole margins, midrib and leaf blade all are greenish in colour. Leaves are long and wide, midrib is prominent, veins are clear. White bloches are present on leaves. The leaves often split along the veins in maturity or in high winds.	 

Items	Morphological characters	Photographs
Inflorescence	Fruit stalk or rachis grows upward through the center of the pseudostem and produces a large inflorescence. Rachis is developed at an angle with the pseudostem. Female flowers develop along the upper inflorescence and male flowers develop along the lower inflorescence. Neutral flowers grow between the female and male flowers. Male flower is big in size, ovoid in shape and sometimes used as vegetable.	
Fruit	Fruits are medium in size, dull yellow in colour, densely seeded, pulp is soft and very sweet but little difficult to eat. Used as desert banana, widely used in preparing local cakes in rural areas. It has some medicinal value.	

3) Local name: Anaji Kala/Kacha kala

Collected from: Gafargaon (Mymensingh), Sylhet and BAU campus

Items	Morphological characters	Photographs
Plant	Anaji kala is a plaintain banana. Samples were collected from Gafargaon {Mymensingh}, Sylhet and BAU campus. The variety is widely cultivated in South-West and North-West part of the country. The plant is quite long, strong and it grows very rapidly. It cannot stand stagnant water, but quite sustainable to drought and cold. It does not require much care and can be grown in comparatively less fertile land.	 
Pseudostem	Pseudostem is quite long and strong, young plants are waxy. Suckers are close to parent (vertical growth). Sparse blotching at the petiole base, black in colour.	 

Items	Morphological characters	Photographs
Leaf	Drooping leaf habit (leaves often split along the veins in maturity or in high winds), long, green colour, midrib is also green. Cigar leaf is yellowish green. The leaves often split along the veins in maturity or in high winds.	
Inflorescence	Fruit stalk or rachis grows upward through the center of the pseudostem, falling vertically. Male bud normal, ovoid shape. Bract apex shape slightly pointed, bract external face purple red and internal face red in colour. Bract behaviour before falling revolute (rolling).	
Fruit	Fruits are medium to large in size (13.6cm – 19.8cm), curved upward, straight or slightly curved in shape and fruit apex is lengthily pointed. Green fruit and male bud used as vegetable	

4) Local name: Bangla Kala

Collected from: Bhola horticulture center, Khagrachhari and Bandarban

Items	Morphological characters	Photographs
Plant	Widely cultivated in Chittagong and Chittagong hill tracks. Fruit medium in size, turns dull yellow when ripen. Soft pulp, good flavour with 2-5 seeds.	

Items	Morphological characters	Photographs
Pseudostem	Pseudostem is medium height, yellowish in colour, shiny not waxy. Suckers are close to parent (vertical growth). Sparse blotching at the petiole base, black in colour.	
Leaf	Intermediate or drooping leaf habit, medium size, wide leaf blade. Midrib and leaf blade is yellowish green. Dull green cigar leaf.	 
Inflorescence	Fruit stalk or rachis grows upward through the center of the pseudostem, falling vertically. Male bud normal, lanceolate shape. Bract apex shape slightly pointed, bract external face purple red and internal face red in colour. Bract behaviour before falling not revolute(not rolling).	 
Fruit	Fruits are medium in size (11.15 cm – 12.77 cm), yellow, curved upward, straight or slightly curved, blunt-tipped apex. Soft pulp, cream colour, good flavour and sweet. TSS value high (28-30%). Used as desert banana.	 
Transverse and Longitudinal section of the fruit		 

5) Local name: Bhuitta Kala/Bichi Kala (Less Seed)

Collected from: Lakhanpur-Gafargaon (Mymensingh) and BAU campus

Items	Morphological characters	Photographs
Plant	Cultivated throughout the country at homestead. Comparatively large tree, high yielding and takes long time (18-20 months) to the fruiting stage. Medium to large fruit, sweet taste with few seeds (a little difficult to eat). Possesses high medicinal value. Tolerant to storm and diseases.	 
Pseudostem	Plants are large in size, blackish green, waxy (white blotches present on suckers). Suckers are close to parent (vertical growth). Sparse blotching at the petiole base. Blotches are black colour.	 
Leaf	Intermediate leaf habit, green large leaves (leaves often split along the veins in maturity or in high winds), midrib prominent also green colour, cigar leaf dull green in colour, there are no blotches on leaves of water suckers.	 
Inflorescence	Fruit stalk or rachis grows upward through the center of the pseudostem, falling vertically. Male bud normal, ovoid shape. Bract apex shape slightly pointed, bract external face purple red and internal face red in colour. Bract behaviour before falling revolute (rolling).	

Items	Morphological characters	Photographs
Fruit	Fruits are dull yellow (sometimes with reddish spot), medium (wide diameter), curved upward, straight or slightly curved, blunt-tipped apex. Soft pulp, cream colour, good flavour, sweet and. less seeded. TSS value high (28-30%). Used as desert banana and in rural areas it is widely used in preparing local cakes.	

6) Local name: Champa Kala/Pahari Champa Kala
Collected from: Khagrachhari, Bandarban (Lama)

Items	Description	Photographs
Plant	Though it is widely cultivated in Chittagong and Chittagong Hill Tracts, it can be seen all over the country. It's quite strong tree, grows 2.8-3 m high. It can not stand stagnant water or with scanty irrigation. Fruits turn golden yellow when ripe, small in size with thin peel, taste sub-acidic and have excellent keeping quality. This variety has got much similarity to Chini Champa kala.	
Pseudostem	Medium height pseudostem, black colour and appearance rough waxy. Suckers are close to parent (vertical growth). Sparse blotching at the petiole base. Blotches are black colour.	

Items	Description	Photographs
Leaf	Intermediate leaf habit, medium size, wide leaf blade and green but midrib is pinkish in colour. Dull green cigar leaf. No blotches on leaves of water suckers.	 
Inflorescence	Fruit stalk or rachis grows upward through the center of the pseudostem, falling vertically. Male bud normal, intermediate shape. Bract apex shape slightly pointed, bract external face purple red and internal face red in colour. Bract behaviour before falling revolute (rolling).	
Fruit	Fruits are golden yellow in colour, small in size. curved upward, straight or slightly curved, bottle-necked apex. Soft pulp, cream colour, good flavour, sweet and. seedless. TSS value high (28-31%). Used as desert banana.	
Transverse section of fruits:		 

7) Local name: Chini Champa Kala
Collected from: Lakhanpur – Gafargaon (Mymensingh)

Items	Description	Photographs
Plant	It is one of the tallest and hardiest cultivar in the country. Though it is widely cultivated in Chittagong and Chittagong Hill Tracts, it can also be seen all over the country. It can be grown under rain-fed condition or with minimal irrigation. Fruits are small, pulp creamy in colour with thin peel. resistant to fusarium wilt.	
Pseudostem	Plants are tall. Pseudostem is yellowish colour with some black strip, appearance rough waxy. Suckers are close to parent (vertical growth). Sparse blotching at the petiole base. Blotches are black colour.	
Leaf	Intermediate leaf habit. Medium size (often split along the veins), green in colour. Pinkish midrib (petiole margins are also pinkish colour). Dull green cigar leaf. No blotches on leaves of water suckers.	 
Inflorescence	Fruit stalk or rachis grows upward through the center of the pseudostem, falling vertically. Male bud normal, intermediate shape. Bract apex shape slightly pointed, bract external face purple red and internal face red in colour. Bract behaviour before falling revolute (rolling).	

<table>
<tr><th>Items</th><th colspan="3">Description</th><th>Photographs</th></tr>
<tr><td>Fruit</td><td colspan="3">Fruits are golden yellow in colour, small to medium in size(9.22cm – 12.71cm), diameter: 3.21cm – 4.06cm, curved upward, straight or slightly curved, bottle-necked apex. Soft pulp, cream colour, good flavour, sweet and. seedless. TSS value high (26 - 30). Used as desert banana.</td><td>   </td></tr>
<tr><td>Transverse section and Longitudinal section of fruits</td><td colspan="3"></td><td>   </td></tr>
<tr><td rowspan="7">Dry weight</td><td></td><td>Fresh weight</td><td>Dry weight</td><td rowspan="7"></td></tr>
<tr><td>Pulp</td><td>50 g</td><td>13.79 g</td></tr>
<tr><td>Peel</td><td>20 g</td><td>3.29 g</td></tr>
<tr><td>Pulp</td><td>40 g</td><td>11.21 g</td></tr>
<tr><td>Peel</td><td>16 g</td><td>2.65 g</td></tr>
<tr><td>Pulp</td><td>49 g</td><td>13.46 g</td></tr>
<tr><td>Peel</td><td>20 g</td><td>3.22 g</td></tr>
</table>

8) Local name: Deshi Sabri Kala
Collected from: Barsal, Norsindi, Muktagacha and ShatKhira

Items	Description	Photographs
Plant	It mainly grows in North -Western part of Bangladesh. The plant grows very fast, has blackish green pseudostem. The margins of the petiole and leaf sheath are reddish. The fruit is medium in size, very tasty, sweet flavour and completely seedless.	
Pseudostem	Plants are tall. Pseudostem is yellowish colour with some black strip, appearance shiny. Suckers are close to parent (vertical growth). Sparse blotching at the petiole base. Blotches are black colour	
Leaf	Drooping type leaf habit. Medium size (often split along the veins), green in colour, midrib dull green. Cigar leaf is also dull green in colour. No blotches on leaves of water suckers.	 
Inflorescence	Fruit stalk or rachis grows upward through the center of the pseudostem, falling vertically. Male bud normal, intermediate shape.Bract apex shape slightly pointed, bract external face purple red and internal face red in colour. Bract behaviour before falling revolute (rolling).	

Items	Description	Photographs
Fruit	Fruits are yellow in colour, small to medium in size, curved upward, straight or slightly curved, blunt-tipped apex. Soft pulp, cream colour, good flavour, sweet and. seedless. TSS value high. Used as desert banana.	

9) Local name: Doyra/Doya Kala
Collected from: ShatKhira (Debhata), Bagerhat (Kashimpur)

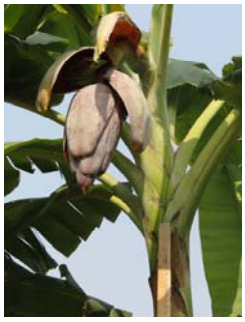
Items	Description	Photographs
Plant	There are two types of Doya kala; Locally named as Tulshi Doya which has soft white seed and Jhama Doya which has black hard seed. It helps as a protective measure against growth of worms and contributes significantly against dehydration of human body.	
Pseudostem	Plants are tall. Pseudostem is yellowish green colour, appearance shiny. Suckers are close to parent (vertical growth).	
Leaf	Intermediate type leaf habit. Medium size, green in colour, midrib dull green. Cigar leaf is also dull green in colour. No blotches on leaves of water suckers.	 

Items	Description	Photographs
Inflorescence	Fruit stalk or rachis grows upward through the center of the pseudostem, falling vertically. Male bud normal, intermediate shape. Bract apex shape slightly pointed, bract external face purple red and internal face red in colour. Bract behaviour before falling revolute (rolling).	
Fruit	Fruits are yellow in colour, medium in size, curved upward, straight or slightly curved, blunt-tipped apex. Soft pulp, cream colour, good flavour, sweet and. densely seeded. TSS value high. Used as desert banana.	

10) Local name: Garasundari/Ganasundari Kala

Collected from: Lakhanpur-Gafargaon (Mymensingh) and BAU campus

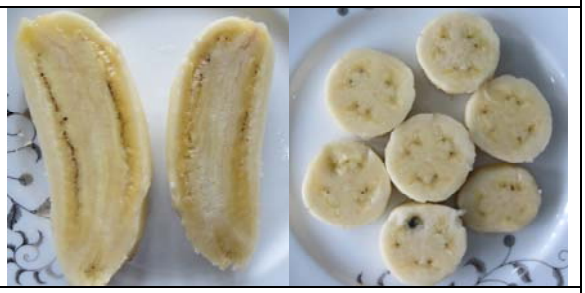
Items	Description	Photographs
Plant	Plants are tall in size, fruits are small with less seed, dull yellow in color.	
Pseudostem	Plants are tall. Pseudostem is yellowish green colour, appearance waxy. Suckers are close to parent (vertical growth). Sparse blotching at the petiole base. Blotches are black colour.	

Items	Description	Photographs
Leaf	Drooping type leaf habit. Medium size (often split along the veins), green in colour, midrib is also green. Cigar leaf is dull green in colour. No blotches on leaves of water suckers.	 
Inflorescence	Fruit stalk or rachis grows upward through the center of the pseudostem, falling vertically. Male bud normal, intermediate shape. Bract apex shape slightly pointed, bract external face purple red and internal face red in colour. Bract behaviour before falling revolute (rolling).	 
Fruit	Fruits are dull yellow in colour, small in size, curved upward, straight or slightly curved, blunt-tipped apex. Soft pulp, cream colour, good flavour, sweet and. less seeded. TSS value high. Used as desert banana.	 
Transverse section and Longitudinal section of fruits		 

11) Local name: Jat Kala

Collected from: BAU campus

Items	Description	Photographs
Plant	Plants are tall in size, fruits are small with less seed, dull yellow in color.	
Pseudostem	Plants are tall. Pseudostem is green colour, appearance shiny. Suckers are close to parent (vertical growth). Sparse blotching at the petiole base. Blotches are black colour.	
Leaf	Intermediate type leaf habit. Large size (often split along the veins), green in colour, midrib is also green. Cigar leaf is green in colour. No blotches on leaves of water suckers	 

<table>
<tr><th>Items</th><th colspan="3">Description</th><th>Photographs</th></tr>
<tr><td>Inflorescence</td><td colspan="3">Fruit stalk or rachis grows upward through the center of the pseudostem, falling vertically. Male bud normal, intermediate shape. Bract apex shape slightly pointed, bract external face purple red and internal face red in colour. Bract behaviour beforefalling revolute (rolling).</td><td>  </td></tr>
<tr><td>Fruit</td><td colspan="3">Fruits are yellow in colour, small in size, curved upward, straight or slightly curved, lengthily pointed apex. Soft pulp, light cream colour, good flavour, sweet and. less seeded. TSS value high. Used as desert banana.</td><td>  </td></tr>
<tr><td>Transverse section and Longitudinal section of fruits</td><td colspan="3"></td><td>  </td></tr>
<tr><td rowspan="4">Dry weight</td><td></td><td>Fresh weight</td><td>Dry weight</td><td rowspan="4"></td></tr>
<tr><td>Pulp</td><td>20 g</td><td>6.22-6.78 g</td></tr>
<tr><td>Peel</td><td>20 g</td><td>3.21-3.58 g</td></tr>
<tr><td>Seed</td><td>14 g</td><td>0.11 g</td></tr>
</table>

12) Local name: Kabri Kala
Collected from: Bhola Horticulture Centre, Norsindi, Lakkhanpur- Gaforgaon and Fulbaria

Items	Description	Photographs
Plant	This variety also known as shail, thutae and manua at different locality and can be grown without much care. Plant is hardy, fruits are very sweet, light yellow in colour and contain a few seeds in most cases.	
Pseudostem	Plants are medium in size and hardy. Pseudostem is pinkish yellow in colour, appearance shiny. Suckers are close to parent (vertical growth). Sparse blotching at the petiole base. Blotches are black colour.	 
Leaf	Drooping type leaf habit. Large size (often split along the veins), green in colour, midrib is pinkish yellow. Cigar leaf is dull green in colour. No blotches on leaves of water suckers.	 

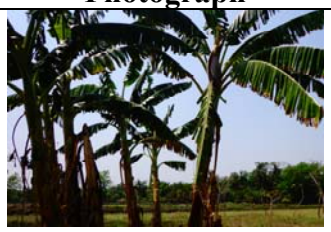
<table>
<tr><th>Items</th><th>Description</th><th>Photographs</th></tr>
<tr><td>Inflorescence</td><td>Fruit stalk or rachis grows upward through the center of the pseudostem, falling with a curve. Male bud normal, intermediate shape. Bract apex shape slightly pointed, bract external face purple red and internal face red in colour. Bract behaviour before falling not revolute (not rolling).</td><td>   </td></tr>
<tr><td>Fruit</td><td>Fruits are yellow in colour, small in size, curved upward, straight or slightly curved, blunt-tipped apex. Soft pulp, light cream colour, good flavour, sweet and. less seeded. TSS value high. Used as desert banana.</td><td>   </td></tr>
<tr><td>Transverse section and Longitudinal section of fruits</td><td></td><td>   </td></tr>
<tr><td>Dry weight</td><td colspan="3"><table><tr><td></td><td>Fresh weight</td><td>Dry weight</td></tr><tr><td>Pulp</td><td>86 g</td><td>28.49 g</td></tr><tr><td>Peel</td><td>41 g</td><td>6.19 g</td></tr><tr><td>Pulp</td><td>69 g</td><td>23.06 g</td></tr><tr><td>Peel</td><td>36 g</td><td>4.22 g</td></tr><tr><td>Pulp</td><td>78 g</td><td>24.36 g</td></tr><tr><td>Peel</td><td>30 g</td><td>4.01 g</td></tr></table></td><td></td></tr>
</table>

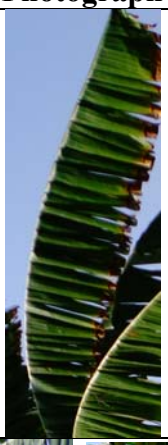
13) **Local name: Kanthali Kala**
Collected from: Govt. Horticulture Centre, Barisal and Pirozpur

Items	Description	Photographs
Plant	This variety is commonly cultivated in southern districts and popular for its flavour which is reminiscent of jackfruit, hence kanthali, a derivation of kanthal. It is used as a home remedy for treating dysentery. One more variety was collected from Dumuria, Shatkhira; which is used as plantain banana.	
Pseudostem	Plants are medium in size and strong. Pseudostem is pinkish yellow in colour, appearance shiny. Suckers are close to parent (vertical growth). Sparse blotching at the petiole base. Blotches are black colour.	
Leaf	Drooping type leaf habit. Medium to large size (often split along the veins), green in colour, midrib is pinkish yellow. Cigar leaf is dull green in colour. No blotches on leaves of water suckers.	 

Items	Description	Photographs
Inflorescence	Fruit stalk or rachis grows upward through the center of the pseudostem, falling vertically. Male bud normal, ovoid shape. Bract apex shape slightly pointed bract external face purple red and internal face red in colour. Bract behavior before falling revolute (rolling).	
Fruit	Fruits are yellow in colour, small in size (similarities with the Champa kala but large in diameter), curved upward, straight or slightly curved, blunt-tipped apex. Soft pulp, light cream colour, good flavour, sweet. TSS value high. Used as desert banana.	  
Transverse section and Longitudinal section of fruits		 

14) Local name: Kulpat/Pulpat Kala
Collected from: Kashimpur, Bagerhat

Items	Description	Photograph
Plant	This variety is commonly cultivated in southern districts and popular for its softness and sweetness. Plants are tall.	
Pseudostem	Pseudostem is yellowish in colour, appearance rough. Suckers are close to parent (vertical growth).	

<table>
<tr><th>Items</th><th>Description</th><th>Photograph</th></tr>
<tr><td>Leaf</td><td>Drooping type leaf habit. Medium to large size (often split along the veins), green in colour, midrib is yellowish green. Cigar leaf is dull green in colour. No blotches on leaves of water suckers.</td><td>  </td></tr>
<tr><td>Inflorescence</td><td>Fruit stalk or rachis grows upward through the center of the pseudostem, falling vertically. Male bud normal, ovoid shape. Bract apex shape slightly pointed, bract external face purple red and internal face red in colour.</td><td>   </td></tr>
<tr><td>Fruit</td><td>Fruits are dull yellow in colour, small in size (13.03cm-13.58cm), diameter (3.14cm – 4.01cm), curved upward, straight or slightly curved, blunt-tipped apex. Soft pulp, light cream colour, good flavour, sweet and less seeded. TSS value high (29.8 – 32%).Used as desert banana.</td><td>   </td></tr>
<tr><td>Transverse section and Longitudinal section of fruits</td><td></td><td>   </td></tr>
<tr><td>Dry weight</td><td colspan="3"><table><tr><td></td><td>Fresh weight</td><td>Dry weight</td></tr><tr><td>Pulp</td><td>46.17 g</td><td>15.86 g</td></tr><tr><td>Peel</td><td>30 g</td><td>5.03 g</td></tr><tr><td>Pulp</td><td>41.02 g</td><td>14.16 g</td></tr><tr><td>Peel</td><td>30 g</td><td>4.76 g</td></tr><tr><td>Pulp</td><td>40.88 g</td><td>14.41 g</td></tr><tr><td>Peel</td><td>30 g</td><td>5.01 g</td></tr></table></td><td></td></tr>
</table>

Besides these some more cultivated varieties were collected from different area of country for characterization. The area of collection of these are stated below:

Sl. No.	Name of indigenous banana variety	Where they grown
1	Thaitta Kala	Collected from Dumuria, Old Shatkhira, mostly used in Puja. Moderately soft, small, less seeded and sweet.
2	Shathi/Modna Kala	Collected from Lakhikunda, Ishurdi, it also used in puja.
3	Mortoman Kala	Collected from Dumuria and Ghuddirdanga, Old Shatkhira.
4	Jeen Kala	Collected from Karapara Bazar, Bagherhat. This variety is rapidly diminishing from the area.
5	Joltoronga/Panitoronga	Collected from Dumuria, Old Shatkhira, used as plantain banana.
6	Rumki Kala	Collected from Rajbari
7	Shail Kala	Collected from Sylhet Sadar, less seeded
8	Guma/Gara	Collected from Durgapure/Netrokona
9	Manik	Collected from Naogan
10	Bashonti Sagar Kala	Collected from Velabari, Lalmonirhat
11	Malbhog Kala	Collected from Velabari, Lalmonirhat
12	Manua Kala	Collected from Velabari, Lalmonirhat
13	Mastakbihin Kala	Collected from Velabari, Lalmonirhat
14	Hati Dudh Kala	Collected from Bandarban

11. Research Highlights (bullet points-max.10 nos.):

Major technical activities in relation to the objectives + others	Achievements/Results
1. To characterize the morphological features of GI crop varieties (guava and jujube) and BAU-GPC released mango varieties.	1. Morphological characterization of two GI crops varieties (guava and jujube) and BAU-GPC released mango varieties have been successfully completed.
2. To characterize GI crop varieties (guava and jujube) at molecular level using RAPD markers.	2. (a) Molecular characterization of jujube has been done using RAPD marker. (b) DNA extraction of GI guava has been done successfully.
3. To characterize GI aroids and indigenous banana.	3. Morphological characterization of GI aroids and indigenous banana has been completed.

12. Environmental matrix

a) Before experimentation

Sl. No.	Environmental issue	Component	Improvement/deterioration*				Remarks
			Small	Moderate	Large	None	
1	Biodiversity	Flora				-	
		Fauna				-	
		Genetic diversity				-	
		Exotic varieties				-	
		Local varieties/cultivars				-	
		Hybrids				-	
2	Soil quality	Organic matter				-	
		Chemical fertilizer use				-	
		Soil salinity				-	
		Fertility status				-	
		Microbial activity				-	
		Heavy metal contamination				-	
		Water quality				-	
3	Agro- Chemicals	Pesticide use				-	
		POPs				-	
		IPM				-	
		Pest infestation				-	
		Bio-pesticides				-	
		Health hazard				-	
4	Pollution	Soil				-	
		Water				-	
		Air				-	

Note:

- Small (less than 20%), moderate (between 20-25%) and large (over 50%)
- '+' sign has been used for improvement and '-' sign for deterioration.

b) After experimentation

Sl. No.	Environmental issue	Component	Improvement/deterioration*				Remarks
			Small	Moderate	Large	None	
1	Biodiversity	Flora		+			
		Fauna					
		Genetic diversity			+		
		Exotic varieties	+				
		Local varieties/cultivars			+		
		Hybrids				-	
2	Soil quality	Organic matter		+			
		Chemical fertilizer use				-	
		Soil salinity				-	
		Fertility status				-	
		Microbial activity				-	
		Heavy metal contamination				-	
		Water quality				-	
3	Agro- Chemicals	Pesticide use				-	
		POPs				-	
		IPM		+			
		Pest infestation				-	
		Bio-pesticides				-	
		Health hazard				-	
4	Pollution	Soil				-	
		Water				-	
		Air				-	

Note:

- Small (less than 20%), moderate (between 20-25%) and large (over 50%)
- '+' sign has been used for improvement and '-' sign for deterioration.

13. Major Attainments *(in relation to the set objectives)*:

a. Technical : Output, Outcome and Impact

Sl. No	Major technical activities performed in respect of the set objectives	Output(i.e product obtained, visible, measurable)	Outcome(short term effect of the research)	Impact (long term effect of the research)	Remarks (reason, if anything otherwise plus any other)
1.	Characterization of GI guava varieties	Out of four GI guava varieties viz. Mukundapuri, Sawupkanti, Kanchan Nagar, Sayedi were characterized	All GI guava varieties has been morphologically characterized	Varietal protection can be ensured for long term basis; further research may tune from the base of this study	None
2.	Characterization of GI jujube (ber/kul) varieties	Out of six GI varieties jujube viz., Apple kul, Shabjee kul, Zahazi kul, Khacchar kul, Narikeli kul and Kachua kul were characterized	All GI jujube (ber/kul) varieties has been characterized successfully	Varietal protection can be ensured for long term basis; further research may tune from the base of this	

Sl. No	Major technical activities performed in respect of the set objectives	Output(i.e product obtained, visible, measurable)	Outcome(short term effect of the research)	Impact (long term effect of the research)	Remarks (reason, if anything otherwise plus any other)
				study	
3.	Characterization of BAU-GPC released 17 mango varieties	Seventeen released mango varieties	Seventeen released varieties has been characterized	Varietal protection can be ensured for long term basis; further research may tune from the base of this study	
4.	Characterization of GI aroids crops	Characterization of GI aroid crops like Giant taro (Man kachu), Elephant foot yam, Panchamakhi kachu, Poidnal kachu, Salad kachu, Tannia/Dud kachu, Blue taro (Surma kachu), Pani kachu/Shola kachu, Shahebi kachu/Babu kachu and Mukhi kachu	Characterization of GI aroid crops like Giant taro (Man kachu), Elephant foot yam, Panchamakhi kachu, Poidnal kachu, Salad kachu, Tannia/Dud kachu, Blue taro (Surma kachu), Pani kachu/Shola kachu, Shahebi kachu/Babu kachu and Mukhi kachu has been completed	Varietal protection can be ensured for long term basis; further research may tune from the base of this study	
5.	Characterization of indigenous banana	Characterization of indigenous banana like Agnissar, Aitta, Anaji, Bangla, Bhuita/Bichi, Champa, Chinicahmpa, Deshi Sabri, Doyra/Doya, Garasundari/Ganasundar, Jat, Kabri, Kanthali, Kulpat/Pulpat kala	Characterization of indigenous banana like Agnissar, Aitta, Anaji, Bangla, Bhuita/Bichi, Champa, Chinicahmpa, Deshi Sabri, Doyra/Doya, Garasundari/Ganasundari, Jat, Kabri, Kathali, Kulpat/Pulpat kala has been completed	Varietal protection can be ensured for long term basis; further research may tune from the base of this study	

b. Procurement (Please see appendix I)

Sl. No	Approved provisions of Procurement *(list major items)*	Achievement	% of achievement	Remarks (statement on the handing over of the materials procured/developed as per LoA plus any other)*
1.	Cooled incubator (-20^0C)	Purchased	100	
2.	Color chart	Purchased	100	
3.	Ice box	Purchased	100	
4.	Computer & printer	Purchased	100	
5.	Digital Refractometer	Purchased	100	
6.	Digital Slide calipers (2)	Purchased	100	

*** All equipments are in good and working condition.**

c. HRD/ Training: None

Title (e.g Ph.D/MS/ Trainings, workshops conducted etc.)	Target	Attainments	No. of participants	Benefit of the higher studies/trainings(application of the learning, productivity enhancement	Remarks (reason, if anything otherwise)

d. Financial

Sl. No	Major Head	Fund received (Tk.)	Expenditure (Tk.)	Balance/Unspent (Tk)	Remarks (reason, if anything otherwise)
A.	Salary & Remuneration	3882,320/-	873,330/-	0.00	
B.	Research expenses		1536,366/-		
C.	Operating expenses		442,374/-		
D.	Fuel, oil & maintenance		344,844/-		
E.	Seminar/workshop		70,000/-		
F.	Publication & printing		30,000/-		
G.	Contingences		167,397/-		
H.	Capital expenses		618,000/-		
		3882,320/-	**3882,320/-**	**0.00**	

e. Materials developed/Publications made:

Type of material/publication	Title	Number	Remarks(being used by/meant for/any other)
Technology development			
Process development			
Information development	Characterization of Important Plant Genetic Resources		
Journal publication			
Books/Monographs/Manual published			
Booklet/leaflet/flyer etc. published			
Any other (patenting of technology etc.)			

14. Sub-project Auditing (cover all types of audit performed)

Types of Audit (e.g BARC/Implementing agency/FAPAD/World Bank/others)	**Major observations/issues/objections raised, if any**	**Status at the sub-project end**	**Remarks**
FAPAD	No objection found	Completed	
J.U. Ahmmed & Co.	No objection found	Completed	

15. Reporting

Report type	**Actual date of submission(s)**	**Total Number(s)**	**Remarks (if anything otherwise)**
a. Inception report	03.01.2012	01	
b. Monthly reports*		23	
c. Statement of expdts.(SoE)*		23	
d. Quarterly report(s)*			
e. Six monthly report	16.6.2013		
f. Procurement plan			
g. Annual research program format	14.02.2013		
h. Environmental monitoring (Annual Basis)			
i. Social safeguard status (Before and at the end)			
j. Field Monitoring Report(s)**	03.09.2013		

** Provide all since start to end.*

*** Conducted at the local level by implementing agencies.*

16. Problèmes/Contraints (Bullet points- max. 5 nos.):
Limitation in finding of approprite person for recording true historical background of GI crops, interrupted electricity during molecular study, Sayedi piayara is no more existed in the field.

17. Suggestion for future, if any:
This project should be continued for refinement with more molecular markers and characterization of more GI crop varieties. Characterization of newly included crops like GI aroids and indigenous banana should be continued.

Signature of the Coordinator/Principal Investigator (as applicable)

_____
(Prof. Dr. M. A. Rahim)
Date:
Seal

Counter signature of the Head of the agency/authorized representative

_____
(Prof. Dr. Lutful Hassan)
Director, BAURES
Date:
Seal

References

Doyle, J.J. and Doyle, J.L. 1990. Isolation of plant DNA from fresh tissues. Focus. 12: 13-15.

Elo, K.S., Ivanoff, J.A., Vourinen and Piironen. 1997. Inheritence of RAPD markers and detection of inter-specific hybridization with brown trout Atlantic salmon. Aquaculture, 152: 55-65.

Nei, M. 1972. Genetic distance between populations. Am. Nat., 196:283-292.

Nei, M. 1973. Analysis of gene diversity in subdivided populations. Pro. Nat. Acad. Sci. USA, 76: 5269-5273

Welsh, J. and McClelland, M. 1990. Fingerprinting genomes using PCR with arbitrary primers. Nucleic Acid Res., 18:7213-7218.

Williams, J.G.K., Kubelic, A.R., Livak,. K.j., Rafalski, J.A. and Tingey, S.V. 1990. DNA polymorphisms amplified by arbitrary primers are useful as genetic markers. Methods Enzymols. 218:704-740.

Yeh, F.C., Yang, R.C. and Boyle, T. 1999. POPGENE VERSION 1. 13: Microsoft Window-based Free Ware for Population Genetic Analysis. ftp://ftp Microsoft.com/softlib /HPGLEXE

Appendix I

List of Capital Expenses:

Capital expenses has been used to buy small equipment's, tools, furniture and supplies which are given below. It is mentioned that all the items are ready to use for future study:

Sl No	Particulars	Unit	Quantity	Total	Users
A. Furniture					
1	Furniture (Books & Chemicals shelf)	No.	2	38,000/-	BAU Hort. Lab
B. Tools and Equipments					
1	Computer (Desktop)	No.	1	45,200/-	BAU Hort. Lab
2	Laser printer	No.	1	40,150/-	BAU Hort. Lab
3	Digital camera (Sony EOS)	No.	1	64,300/-	BAU Hort. Lab
4	Digital slide calipers	No.	3	57,000/-	BAU Hort. Lab
5	Digital refractometer	No.	1	103,000/-	BAU Hort. Lab
6	Color chart	No.	1	28,000/-	BAU Hort. Lab
7	Digital pH meter	No.	1	54,000/-	BAU Hort. Lab
8	Magnetic stirrer	No.	1	20,000/-	BAU Hort. Lab
9	Deep freezer (-20 ^{o}C)	No.	1	151,600/-	BAU Hort. Lab
C. Motor cycle/bi-cycle					
1	Bi-cycle	No.	2	20,000	In the Field
	Total (A+B+C)			**649,250/-**	

(Prof. Dr. M. A. Rahim)
Principal Investigator

(Prof. Dr. Lutful Hassan)
Director, BAURES